THE GLASS INDUSTRY

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CARTON CONVEYING AT THE MARYLAND GLASS CORPORATION

Like Topsy in the story "Uncle Tom's Cabin," quite a few glass plants "just grow'd." This is particularly true of the Maryland Glass Corporation, which, due to its being bounded on the east by an industrial plant, and on the south and west by railroads, could only expand in one direction. This one-direction expansion has resulted in the ware storage sheds being some distance away from the packing department. In addition, the basic design of the plant is such that all warehouses are on the ground level, while the packing department is on the second floor level. With a situation such as this, it was necessary to use a roller conveyor system in order to transfer the ware from the packing department to the ware storage sheds. Last year, when it became necessary to re-vamp the handling methods used in the carton department and packing department, the experience gained by the long-continued use of the conveyor systems already existing was used as a guide.

The changes made may be best illustrated by comparing the old system with the new. In the former set-up, knocked down cartons, partitions and liners were received by truck and carried by elevator to the third floor of a building directly opposite the packing department. The cartons were then formed and sealed on a carton machine, the partitions and liners inserted, and the cartons manually transferred to the packing department on the second floor of the opposite building. The empty cartons were then distributed manually to the packers at each lehr. After filling, the cartons were again manually transferred from the packing station to a master conveyor, which carried them to the various ware storage sheds.

The first step in the re-vamping program was to change the method of sealing the cartons. With the carton sealing machine, several operators were required for each machine during the day shift in order to supply sufficient cartons for a twenty-four hour period. If, for any reason, the job was changed during the night shift, an over supply of sealed cartons was the result, and in order to conserve space, it was necessary to unseal the cartons. It

Fig. 1. Overall view of the Bliss Bottom Stitcher used in the carton department.

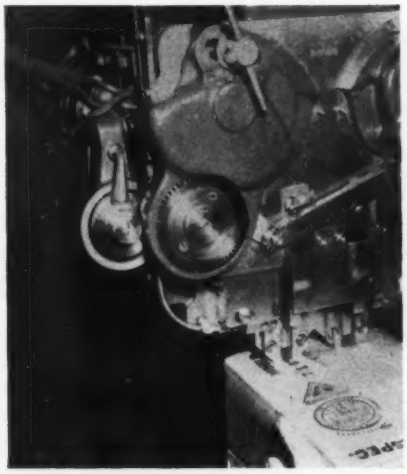


Fig. 2. Close-up of the stitcher, indicating the method of its operation.

Fig. 3. Gravity roller conveyor which supplies cartons from the carton department to the packing department.

Fig. 4. View of the conveyor system inlet used at a position directly above the packing department.

was decided, therefore, that stapling machines be substituted for the carton sealing machines. It has been found that by the use of this type of machine only one operator is required, instead of the several formerly used, and that the cartons may be made as needed, instead of in advance. In addition, it has been found that better and more secure cartons could be formed with the stapling machine. Oftentimes insufficient glue would be applied by the carton sealing machine, with the result that when the cartons were filled the flaps would open. At present, three Bliss Model HGU 15" duplex bottom stitchers are being used. These were supplied by the Dexter Folder Company and are shown in Figures 1 and 2.

Instead of manually transferring the cartons from the carton department to the packing department, gravity roller conveyors have been installed. Figure 3 illustrates the method adopted for the transfer of the cartons from the carton department, located on the third floor of the building opposite the packing department, to the exit end of the lehrs, located on the second floor of the factory building proper. In the design of this system full advantage has been taken of the use of gravity. In Figure 4 the method of supplying cartons from that part of the carton department directly above the packing department to the lower floor is shown.

As the cartons enter the packing department they are shunted to their respective lehrs by the means of curves and inclines. These can be seen in Figure 5. When the empty carton reaches the packing end of the lehr the packer takes the carton from the conveyor and places it on a tilt buck. After being filled, the buck is tilted and the carton pushed onto an inclined roller conveyor, where it is transferred by gravity to the master conveyor. At the end of each lehr conveyor is a stop that holds the ware until it has been counted. This stop is then released by a foot pedal and the cartons shunted on to the master conveyor.

Previous to this modernization program, the packers' off-ware was placed in trays and manually transferred to cullet chutes. Figure 6 shows the new method of off-ware cullet disposal. The off-ware is placed in hinged trays located to one side and slightly above the packer. When the tray is full it is tilted by hand and emptied into a chute which carries it to a truck located on the ground floor. In Figure 7 a view of one of the Crescent trucks used for receiving the off-ware cullet is shown. When the truck is full, it is picked up by an electrical tractor and taken to the cullet bins. The cloth hood which is placed around the top of the truck is used as a safety measure and prevents broken pieces of glass from flying out of the truck and striking those passing by.

The master conveyor, which receives the packed ware from the auxiliary conveyors running from each lehr, extends the entire length of the packing department. As a single master conveyor is insufficient to meet the requirements of all the lehrs, a second master conveyor has been installed above and half-way along the length of the first conveyor. This conveyor is used for the ware coming from the three end shops. A belt type booster conveyor is used to take the ware from the three lehr conveyors to the overhead master conveyor and is shown in Figure 8. The belt used on this booster conveyor is a

Fig. 5. (left) A section of the packing department showing the conveyors which supply cartons to the packers, and the auxiliary conveyors used to transfer the packed cartons to the master conveyor. Fig. 6. The off-ware cullet disposal system is above and to one side of the packers.

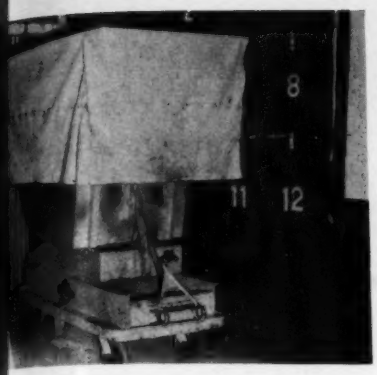


Fig. 7. The packing department cullet falls into this cullet truck which is covered by a safety hood to prevent broken glass from flying about.

Fig. 8. The booster conveyor takes ware from the lehr conveyor to the master conveyor. This is equipped with special non-skid belting.

Fig. 9. Showing the lower end of the overhead master conveyor. Note the hinged section which can be dropped to the conveyor line below it.

special crepe rubber, non-skid type of belting. Being non-skid in character, a very steep angle of elevation may be used. A special gear head motor, supplied by the Master Electric Company, is used to drive this booster conveyor. The lower end (Figure 9) of this overhead conveyor is hinged so that it may be dropped down to meet the main master conveyor, thus transferring the ware to the lower conveyor.

The various packed cartons are then segregated on the master conveyor and are manually pushed to the warehouse distributing conveyors shown in Figure 10. These two conveyors are both gear head type motor driven belt conveyors and run outside of the packing department (Figure 11) under an enclosed shed, into the ware sheds where the ware is then conveyed to the various storage positions by the means of gravity roller conveyors and booster conveyors such as were previously described. In the ware storage sheds, roller conveyors criss-cross each other and divide the warehouses into different sections. Ball transfers are used at each criss-cross and allow the ware coming in to be shifted to any warehouse position. The total amount of roller conveyor in use is estimated to be about 6000 running feet and was supplied by the Mathews Conveyor Company.

To prevent jamming of the ware at those positions where the belt conveyors meet the roller conveyors, both in the packing department and in the ware storage sheds, General Electric photoelectric cells and relays are used. These are located in such a position that if the run becomes blocked, a carton will intercept the light beam and if intercepted for more than ten seconds will cause

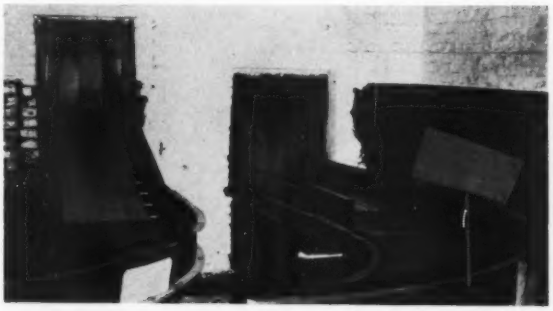


Fig. 10. The conveying lines at the end of the master conveyor.

the relay to operate and shut off the motors driving the belt conveyors. When the interception stops the circuit is again completed and the conveyor is automatically restarted. The arrangement of the photoelectric cells and relays is shown in Figure 12.

The same conveyor lines used in the warehouse for shifting the ware to the various locations are extended so that they reach to the various doors of the warehouses and allow the loading of both freight cars and trucks. In truck loading a portable light weight aluminum roller conveyor, about 10 feet in length, is used. This conveyor may be carried by one man to various positions and also may be placed on the truck for unloading of the ware.

This system of conveying ware, while it does not represent anything new or revolutionary, does show what can be achieved by existing methods of material handling under adverse conditions.

Fig. 11. Belt conveyors transfer ware from the packing department to the ware storage sheds.

Fig. 12. General Electric photoelectric cells and relays prevent jamming of the cartons on the conveying lines.

REMOVING MOISTURE FROM COMPRESSED AIR

By L. I. BUNCE
Hartford Empire Company

Moisture in compressed air is a continual source of trouble in the operation of machinery and in some types of burners, in glass factories. The source of this moisture is the water vapor, ordinarily present in varying amounts in atmospheric air, which passes through the compressor and is carried by the compressed air until it condenses in the pipe lines, the valves and cylinders of the forming machines, etc.

The most practical way of really removing moisture from compressed air is by the use of an "aftercooler." These should be distinguished from so-called "Separators," "Moisture Extractors" and "Dehydrators," all of which claim to remove moisture from compressed air but which actually only remove some portion of the moisture that has already condensed.

Certain physical laws exist regarding the removal of moisture from the air which will give the reader a simple statement of the problems. These will also indicate why aftercoolers are the only efficient equipment to use. But before going into this discussion, it is necessary first to study the effects of pressure and temperature on the amount of water, in the form of vapor that air can carry.

The maximum amount of moisture that air can carry depends on its temperature and pressure. The higher the temperature of the air, the greater the amount of moisture it can carry. The higher the pressure of the air, the smaller the amount of moisture it can carry.

For all practical purposes, when air is compressed, the rise in temperature due to the compression far more than offsets the effect of the rise of pressure on the moisture-carrying capacity of the air. Therefore, all of the moisture which the air carries when it enters the compressor inlet passes into the compressed air system. When a compressor is maintaining 45 lbs. per sq. in. (gage pressure) the temperature of the air as it leaves the compressor is not far from 300° F. As this compressed air cools in the storage tank or in the pipe lines, its moisture carrying capacity is reduced and when the point is reached where the air cannot carry all its moisture (called the dew point), the excess moisture is condensed and it collects in the nearest low point or points of the air system.

The enormous quantity of water passing through an air compressor under certain atmospheric conditions is shown by the following example:

Cubic Feet Free Air per Minute	2000
Intake Pressure	30" Barometer
Final Pressure	45 lb. sq. in. Gage
Temperature Intake Air	80° F.
Relative Humidity Intake Air	70%

(Relative Humidity of 70% is common in U. S. in the summer months. Saturated air has 100% Relative Humidity.)

From well established data it is known that atmospheric air as specified above contains 0.0011 lbs. of water vapor per cubic ft. Therefore, 0.0011 lbs. per cu. ft. × 2000 cu. ft. per minute × 60 minutes per hour × 24 hours = 3168 pounds of water or 380 gallons of water passing into the compressed air system per day, under the atmospheric conditions outlined above.

The evils of water and oil in a compressed air system are legion. A sludge is formed which coats the interior of all pipes, receivers, etc. This not only restricts the passages, but carbonizes on the valves of the compressor, creating a very definite fire hazard.

Numerous fires have been caused by leaky discharge valves allowing the highly heated air to leak back into the compressor cylinders and be recompressed until the temperature is well above the ignition point of the oil sludge. Such a fire, once started, will continue to burn fiercely until the compressor is shut down or until all of the combustible material has been consumed.

In all compressed air systems that are not equipped with aftercoolers the highly heated air immediately begins to cool upon entering the distribution system. When the air has cooled to the dew point, the water and oil vapors begin to condense and are carried along with the air. This is generally deposited in one or more low points in the piping. This cuts down the effective area of the pipes and necessitates carrying a higher compressor pressure, due to the pressure drop through these restricted areas.

Considerable water may be carried into all air actuated mechanisms, washing off the cylinder and valve lubrication. This tends toward sluggish and erratic machine operation.

Trouble is often experienced with low pressure gas-fired forehearths due to sludge condensing and carbonizing in the throats of mixer nozzles. These deposits re-

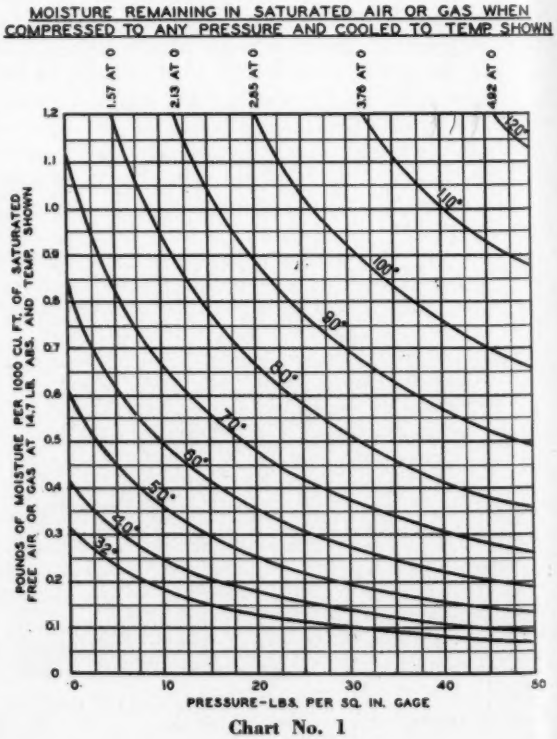


Chart No. 1

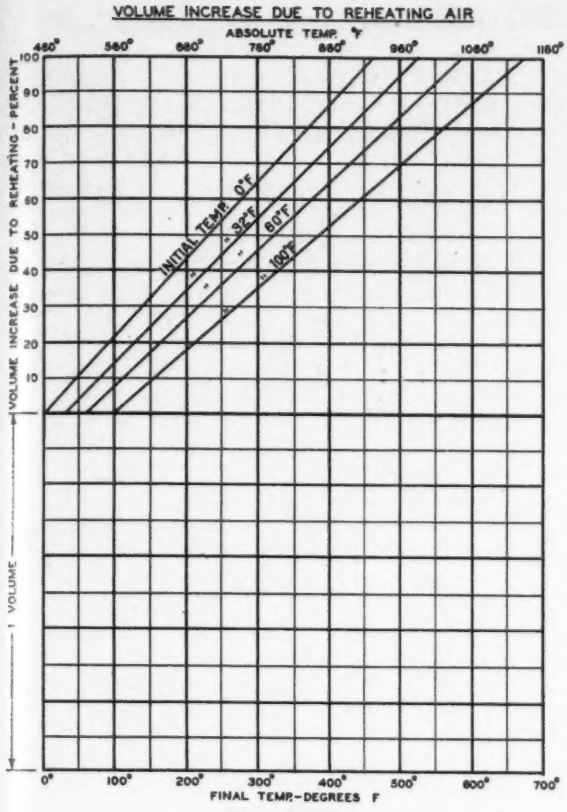

VOLUME INCREASE DUE TO REHEATING AIR
ABSOLUTE TEMP °F
460° 560° 660° 760° 860° 960° 1060° 1160°
VOLUME INCREASE DUE TO REHEATING - PERCENT
100 90 80 70 60 50 40 30 20 10
INITIAL TEMP. 0°F
" 32°F
" 80°F
" 100°F
1 VOLUME
0° 100° 200° 300° 400° 500° 600° 700°
FINAL TEMP-DEGREES F

Chart No. 2

duce the area of the throats and change the gas-air ratio, making it next to impossible to maintain a steady fire.

Earlier it was pointed out that the higher the temperature of the air the greater the amount of moisture it can carry. Conversely the lower the temperature of the air the smaller the amount of moisture it can carry. Therefore, if the hot compressed air discharged by the compressor can be cooled without lowering its pressure, a considerable proportion of its moisture may be condensed. Commercially this is accomplished by the installation of an "aftercooler" as close as possible to the compressor discharge.

There are several types of aftercoolers on the market but their function is the same; namely, to bring the highly heated air into intimate contact with pipes containing cold water, thus cooling the air to such a degree that the greater part of the moisture and oil vapor is condensed and removed from the system through a suitable separator with automatic trap.

An aftercooler is somewhat similar to a condenser used on steam engines, and once installed their operating cost is only that of pumping cooling water through them. An efficient aftercooler will reduce the temperature of the air to within 15° F. of the cooling-water temperature, when about one-gallon of cooling water is used for each one hundred cubic feet of free air compressed per minute. The colder the cooling-water the drier the air leaving the aftercooler.

The percentage of moisture which a well-operated aftercooler will remove depends upon the amount of moisture in the air being compressed, the pressure to which it is being compressed, and the temperature to which it is cooled in the aftercooler. If the air being compressed carries only a very small amount of moisture, the aftercooler may not remove any of it, but such air is dry enough so that it will not cause trouble in the forming machines. If the air being compressed carries a lot of moisture, a well operated aftercooler will remove a considerable portion of the moisture, leaving the air sufficiently dry so that it will cause a minimum of trouble in the forming machines.

Another way of expressing the value of a well operated aftercooler is to say that it is a watch-dog guarding against the passage of excessive moisture into the compressed air system.

Chart No. 1 shows the moisture remaining in saturated air or gas when compressed to a given pressure and cooled to the temperature shown.

Some plants are fortunately so situated that they have practically an unlimited supply of cold water; others must use the water over and over again, cooling it in a spray pond or a cooling tower. If well operated, either system will lower the temperature of the warm return cooling-water from the aftercooler and compressors to practically that of the wet bulb temperature of the atmosphere.

In plants where, for economy, the water is recirculated, and the summer temperatures and humidities are rather high, the temperature of the cooling water may not be low enough for good aftercooler operation. It would then be advisable to install small separators near the end of each pipe line to catch any condensation which has come down in the pipe lines.*

In any commercial compressed air system the air must be cooled to below the dew point temperature before any water can be removed from the air.

It should be emphasized that any increase in the temperature of the compressed air after it leaves the main receiver is beneficial both as to its ability to carry moisture without condensation and to its volume. Pipe lines running through hot parts of the factory, or auxiliary receivers near enough to furnaces or checkers to really absorb waste heat, do increase the temperature of the compressed air and therefore its ability to carry moisture without condensation. This also increases its volume. Chart No. 2 shows the increase in volume due to reheating. (Absolute temperature is degree F. plus 459.6° F., thus air at 60° F. is 60 + 459.6 = 519.6° F. Absolute.)

If air is reheated from 60° to 250° F. the gain in volume is from 30 to 35 per cent and the cost of this volume of air, produced by reheating, is about one-eighth of that required to produce the same volume by compression.

Plants that are running very close to their compressor capacity should seriously consider the increase volume of compressed air obtained from such a reheater utilizing a portion of the waste heat always available.

Aftercoolers are built by most compressor manufacturers and perform to the marker's specifications. The main thing is to have ample volume for the air which is used, and to have an adequate supply of as *cold* cooling water as can be obtained. One point sometimes over-

(*Continued on page* 272)

*It is possible to remove water vapor from air in a desiccator or dehydrator without cooling the air, but this is a physico-chemical reaction that depends on absorption of the water by some chemical reagent. This is purely a laboratory procedure and it is necessary to replace the chemical reagent at frequent intervals.

THE TOLEDO TRIAL

Government attorneys have promised a "whirlwind" finish to the presentation of their side of an anti-trust trial pending in Federal Court in Toledo when the proceedings are resumed June 2 after a three-week recess. Fifteen additional witnesses are to be heard before the Government rests its case and attorneys estimate this will require about two weeks. Whether Judge Frank L. Kloeb then will recess the case for the summer, or whether he will ask defense attorneys to proceed immediately has not been determined.

The three-week recess came as a welcome respite for all concerned with the trial, especially the attorneys who desperately desired time to study the record and prepare to meet the allegations directly when their turn comes.

For two of the major defendants, the Hartford-Empire Co., and the Hazel-Atlas Glass Co., the recess brought with it an order by Judge Kloeb that all the money which the two firms are bound by contract to pay to each other from now until the case is finally adjudicated be impounded in the office of the Clerk of Federal Court in Toledo. The order, requested in a Government motion filed during the progress of the trial, will make of the Clerk's office a depository for more money than ever before was placed in its custody. It is estimated that the funds so tied up will total well over $2,500,000 for each year that the case is in court. The first deposits made under the order May 15 totaled well over half a million dollars—$387,000 by Hartford-Empire Co., and $211,000 by Hazel-Atlas.

The payments are made by the two firms under the general licensing agreements of 1932, by which Hazel-Atlas came under what the Government has called "The Hartford umbrella." Under the contract, which the Government claims is illegal, Hartford-Empire receives a standard royalty on machinery which Hazel-Atlas uses. At the same time Hazel-Atlas receives one-third of the Hartford-Empire net income. In every year except one since the contract was executed the difference between the two amounts has favored Hazel-Atlas, and last year the net to Hazel-Atlas was nearly $500,000.

The Government contends that the arrangement gives Hazel-Atlas a preferred position over its competitors and in the "findings of fact" which Judge Kloeb attached to his order he sustained this claim of the Government.

During the testimony of J. Harrison McNash, president of Hazel-Atlas, he was asked by a Government attorney whether he considered the contract gave him a position of advantage over his competitors. His reply was, "It probably does."

Other evidence has been introduced showing that the terms of the contract between the two firms were kept secret from the remainder of the glass industry until the investigation by the TNEC in 1938. George A. Ball, executive vice president of the Ball Brothers Co., Muncie, Ind., admitted that his firm threatened to bring action against the Hartford-Empire Co., following the TNEC hearings, based on a claim of fraud in that Hazel-Atlas was receiving the rebate.

T. C. Werbe, president of the Lynch Corp., Anderson, Ind., machinery manufacturers, was questioned for three days by the Government attorneys regarding the relationship between his firm and the Hartford-Empire Co. It was developed that in 1933 the Lynch firm entered into a contract with the Hartford-Empire Co., agreeing not to sell machinery to glass manufacturers without consultation as to whether the prospective machinery purchaser was a licensee of Hartford.

Mr. Werbe testified that the arrangement worked out advantageously for his firm, although he declared that he woud not have signed it if there had been another alternative. Mr. Werbe also described with frankness negotiations which he had with other glass firms, including the Owens-Illinois Glass Co., of Toledo, and its president, William E. Levis. Mr. Werbe said he considered Mr. Levis a man of great ability and integrity, as well as a man of substantial resources. "We felt he could be of help to us and he was," Mr. Werbe stated.

During the testimony of I. J. Collins, president of the Anchor-Hocking Glass Co., it was shown that that firm now has entered into the manufacture of heat-resisting ware in competition with the Corning Glass Works. Government attorneys contend that this is one of the early beneficial effects of the present court action.

The Government has gone extensively into the stories behind all the "big deals" which have made history during the past two decades in the glass industry. There has been no disposition on the part of any of the witnesses to withhold any of this information.

Several witnesses have been brought from great distances to testify that they made attempts at one time or another to enter the glass container manufacturing field. In each case cross-examination has tended to show that a thorough investigation was made by Hartford-Empire as to the responsibility of the respective applicants before licenses were denied.

The Government has made much of the so-called "Clarke article" published in the *National Glass Budget* in 1926 giving a complete description of the gob-feeding process. Although the article bore the signature of William P. Clarke, then president of the American Flint Glass Workers Union, it was written, testimony showed, by R. F. Hatch of Hartford. The contention of the Government is that the article was prepared and written for the purpose of influencing the U. S. Patent Office, which was at that time studying a patent dispute between the Hartford-Empire Co., and the Hazel-Atlas Glass Co. It has been shown that the article was introduced in evidence in the patent case.

Exhibits have been introduced showing that in 1932, when the Hartford-Hazel litigation was in the U. S. Circuit Court of Appeals, Hartford-Empire paid $8,000 to Mr. Clarke as a "retainer," and that later Owens-Illinois shared in the payment of this amount. Clarke was given a contract to work as a "labor saving expert" at $25 a day for any time he worked. The contract was for five years. Mr. Hatch was being subjected to severe questioning by Samuel S. Isseks, Government attorney, on May 9, relative to this subject, when the trial was recessed. Mr. Hatch will resume where he left off when the trial reconvenes.

The trial record now fills about 3,500 pages and there are more than 1,200 exhibits.

NEW LABORATORY BUILDING Makes Corning's Research Facilities The Glass World's Finest

The Corning Research Laboratories were the first research laboratories for glass to be established in the United States. With the completion of the new building, which was dedicated less than two months ago, those laboratories today have become the largest and most completely equipped in the United States. That this growth and expansion coincides with the growth and development of organized research in glass in America, is no mere coincidence.

The history of these laboratories is the story of Dr. E. C. Sullivan. It was he who first established them; developed them to their present impressive proportions; who today directs their activities as Director of Research. Dr. Sullivan, however, tells the story differently. He attributes success to the backing he received from the Board of Directors; to the abilities and cooperation of the men who work with him. Conspicuous among the latter are Dr. J. T. Littleton, Jr., assistant director of research, and Mr. W. C. Taylor, director of glass technology.

Dr. Sullivan came to Corning in 1908. He set up a laboratory of sorts in a fourth floor corner of one of the factory buildings, occupying 1200 square feet of space. His staff consisted of two untrained assistants.

The Laboratory got results. In 1913 additional space was added in part of a new mixing-room building, 5440 square feet. However, even this was soon outgrown, and the laboratory personnel snooped about the glass works in search of odd corners it might preempt. Today, by a new building, another 34,300 square feet has been acquired, bringing the total to 61,430. First designated a chemical laboratory, it now contains more physicists on its staff than chemists.

The new laboratory building was erected by The H. K. Ferguson Co. Without any equipment it cost Corning $280,000. Planned for years, executed in 1940, and dedicated in 1941, it embodies the last word in equipment and facilities for research.

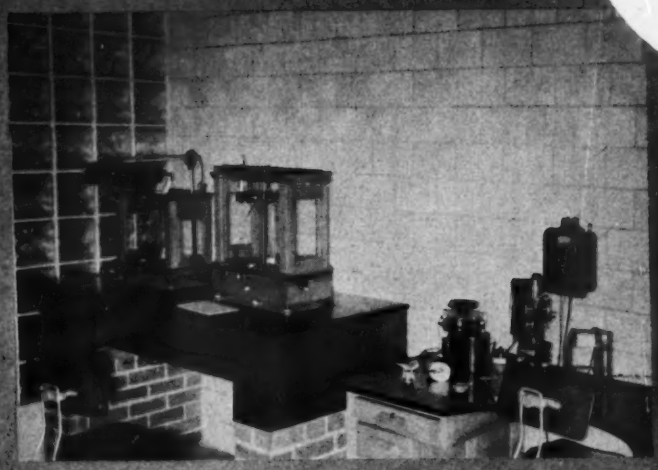
There are four floors. On the first floor are the machine shop, a glass grinding and polishing room, and three large laboratories with their offices. On the second floor are seven laboratories with their offices, a storage room and a projection room. Up another flight are two laboratory suites, the library, stock room, file room, conference room, secretarial room, seven offices, a dark room, and a combined dark room laboratory. The top or fourth floor is the furnace room, storage room, dark and projection room, and another series of seven combination office-laboratories.

Last month Dr. Sullivan granted permission to THE GLASS INDUSTRY to photograph the interiors and to publish this pictorial presentation. The only request he refused was to take a picture of himself seated in his own offices.

Fig. 1. Dr. E. C. Sullivan, founder of the research laboratory of the Corning Glass Works in 1908. Dr. Sullivan headed the laboratory until 1921, when he was made vice president in charge of manufacturing. In 1928 he became president, and in 1930 vice chairman of the Board. His own preference for research and manufacturing led him to return as director of research in 1937, a position he still holds as well as being vice chairman of the Board.

Fig. 2. One end of the library, which is located on the third floor.

Fig. 3. Dr. J. T. Littleton, assistant director of research, seated at his desk. Adjourning his office are the library (Fig. 2) and the secretarial office (Fig. 4).



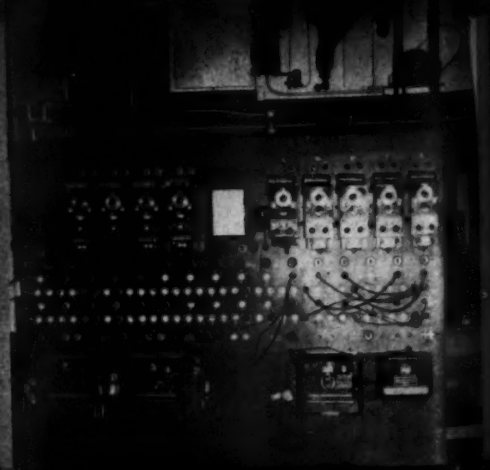


Fig. 4. As can readily be imagined, the stenographic work incidental to a laboratory of this size is considerable. This view shows a corner of the secretarial office, which adjoins the office of the assistant research director (Fig. 3). Miss Catherine Deneen (right), is the personal secretary to Dr. Littleton and has general supervision of the laboratory stenographic staff.

Fig. 5. Laboratory for testing fabricated glass. Workers at the desks are analyzing defects and recording their observations.

Fig. 6. Microscopes and balances. Note particularly the table supporting the latter, as a protection from building vibration. Made of iron and brick, this weighs nearly half a ton. Although such extreme steadiness is unnecessary for ordinary laboratory scales (right), the balance on the left is one of extreme sensitivity.

Fig. 7. A corner of the furnace room, on the fourth floor. Here are housed experimental furnaces, ovens and equipment of varied types involved in the melting of glass.

Fig. 8. One of the physical laboratories, this one located on the third floor. Under the bell jar, center of the picture, a sealed beam headlight is being aluminized.

Fig. 9. The control panel of the fourth floor furnace room. By means of cables, some of which are shown in service, any unit in the department can be precisely controlled.

Fig. 10. A series of ovens under special hoods. This laboratory room is dedicated solely to testing products.

Fig. 11. Routine physical testing laboratory on the second floor. The laboratory assistants are measuring certain properties of regular production glasses.

Fig. 12. Laboratories are so arranged as to comprise complete self contained units so far as possible. In most cases the man in charge of a project has his desk in one corner, as shown here. A more elaborate arrangement is to be seen in Fig. 13.

Fig. 13. A laboratory "suite." The director of the department has his own office, the door to which is open, and his assistant's desk may be seen on the left.

Fig. 14. Corning keeps a constant supply of about 3,000 different chemicals on hand. Here are some of them, in another corner of the stock room.

Fig. 15. The "office" of the stock room, where a running inventory of all supplies is maintained.

Fig. 16. A portion of the machine shop, located on the first floor, which serves both for maintenance and for making any type of special apparatus. Note the high ceiling.

Fig. 17. Third floor conference room. The ceiling is lined with alternate panels of perforated metal, for sound proofing and air conditioning. Above this is a layer of glass wool, serving a similar function. Flush ceiling and fluorescent fixtures illuminate the room.

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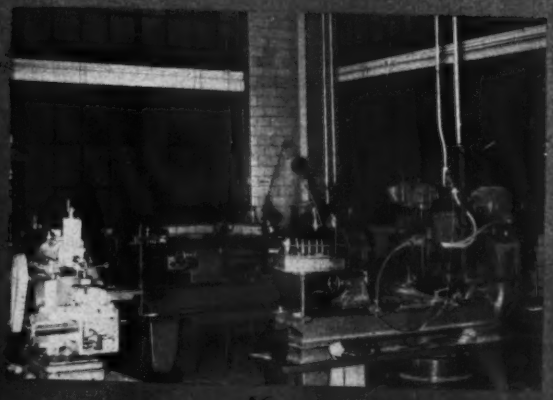

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STAINED GLASS

By JOEP NICOLAS*

It is not from mere curiosity that we study history; nor do historians exist merely for the sake of perpetuating academic science. We cannot get out of history without going through it, which may be why some people consider the art of stained glass as essentially archaic and retrospective. 80 per cent of modern architects, if they have any ideas at all about stained glass, conceive of:

"Poor artists, who since the middle ages go on making such superfluous things as stained glass windows, which take away the better part of precious daylight. They give us a miserable feeling of historical nostalgia, deploring gone-by periods, which in the far distance look much better than they ever could have been. We, the modern, living people; we, the realists, prefer the bright daylight or the splendor of our artificial lightings. We indulge in warm, subdued and indirect light in dining rooms and cocktail lounges. We detest this archaic twinkling of little pieces of colored glass, painfully assembled in windows, imitating the too ceremonious predecessors of our beautifully-made, white, plate glass windows.'

What should I say to contradict such splendid common sense? Well, I simply don't contradict it. I admit it.

The art of stained glass was born from common sense, from a sense of utility. When civilization, in the rear guard of the Roman cohorts, penetrated into Helvetia, Gallia, Transalpina and Rhenania, it met for the first time with very rough climate. The villas of the Roman colonial leaders, unlike the huts and houses of the Gauls and Germans, admitted the daylight through well-shaped "Fenestras" or ornamental screens, cut in stone. These Romans had worked out a system of central heating operated from the basement, and they wanted to keep the cold air out. So the wealthy among them had thin alabaster plates cut to measure and cemented into the sawn out openings of the "fenestrae." We still see alabaster panes in the mausoleum of Galla Placidia in Ravenna and in some other monuments of high antiquity.

Now came from Rome the Egyptian and Phoenician merchants, visiting their customers all over the provinces of the Empire. They carried rarities to the wealthy settlers; sold them everything: dresses and silver and jewels, glass bowls and flasks—and we know that these glass articles were costly, especially the white ones, which were difficult to obtain. Then they introduced a novelty: instead of alabaster panes for the windows, they brought little slabs of glass. One could not saw this material as he could alabaster; he marked the pattern in which to cut it, moistening the outline, and touched it with a red hot iron so that it cracked off.

It was a marvelous material. It let through much more light. Moreover, it came in splendid colors that theretofore were known only in precious stone, like rubies and sapphires and emeralds. The arrangement of these different colors within the stone frames marked a new decorative scheme, which became the direct antecedent of the stained glass window.

How long this system of decorating windows carried on is not exactly known, but we may conclude that it disappeared when the possibility was discovered of binding the glass slabs together with lead strips of a suitable profile. Thereafter the stone screens showed larger openings, just to hold the panels of leaded glass, and these "fenestra" types developed the Roman and Gothic period into the complicated stone designs of rose windows and the fish bladder masonry of the flamboyant style.

The stone screen containing colored glass without lead survives in the Mohammedan mosaic window. But in the northern countries the lead type was generally adopted and survived all the possibilities of a rather complicated cloisonne design of colored and translucent glass surrounded by black contours.

We do not know the exact time of the second great innovation, which enabled them to proceed from ornamental design to human figures; namely, the black trace lines, fired into the glass. All we know is that the oldest specimens in existence, at Augsburg and at Le Mans, and dating from about the middle of the eleventh century, show a degree of perfection that presupposes a considerable period of practice in that technique. Since this period, from which comes to us the oldest existing stained glass windows, coincides with the beginning of writing of history in the monasteries, we may practically consider this moment as the beginning of our history of glass painting. And we see, partially out of these chronicles, partially out of letters and written commissions, and also out of still existing specimens, that this art was adopted quickly and universally all over civilized Europe.

The makers of stained glass not only did cut and fire and lead the pot-metal or colored glass, as we do, but in all probability and certainly in various work shops, they made their glasses themselves. I do not believe that all of the window painters were necessarily glass makers, but certainly many of them were. The reason I do not think that they kept doing both of these jobs throughout all the middle ages is that we see from historical records how many of these artists traveled from one place to another, from one job to another, and that very often they temporarily were installed in adjacent buildings belonging to the cathedral or church for which they were composing the windows. As the making of the pot-metal, the melting of the glass in different colors, required a large space and an enormous quantity of wood, we may conclude that the manufacturers of the glass and these artists were different people. They had their glassworks chiefly amidst the woodlands. Some monasteries, situated in the forests, may have had both their glassworks and their glass painting studios; but in the cities and near the cathedrals the danger of fire must have prevented the artists from making their glasses there.

Whereas at first the monks in their monasteries made the glass windows, the craft later passed into the hands of the younger branches of noble families: "les gentils hommes verriers." And the art of glass making and of glass painting were the only manual labor allowed the nobles, that did not abolish their prerogative of nobility.

One of their privileges was formulated in the following terms: 'those who transport the glasses are exempted from paying any customs, duty or road fees for their wares." We may conclude that the transportation of

(*Continued on page* 274)

*From a paper read before the New York Society of Ceramic Arts, February 21, 1941.

ANTI-REFLECTION FILMS ON GLASS

By A. F. TURNER

Bausch and Lomb Optical Company

EDITOR'S NOTE: *Discovery of methods whereby reflection from glass surfaces can be so completely eliminated as to render the glass invisible, has been widely publicized. The fact that to obtain this extreme result entails conditions that can be realized only in the laboratory is not generally appreciated, and this circumstance has given rise to a flood of suggestions for scientific applications that are fantastic in the extreme. No doubt because of this confusion, the Bausch & Lomb Optical Co. has published in its monthly house organ,* THE FOCUS, *a general discussion of the theory underlying zero reflection or high transmission films, by Dr. A. F. Turner. It appears to be of such general interest, and fills such a much needed want, that we republish the paper here by permission of the editor.*

The amount of light lost from a light beam by reflection when it strikes a glass surface increases with the refractive index of the glass. For ordinary window glass, the loss is 4 per cent per surface; for the heaviest flint glasses, it may amount to 10 per cent. For a plate of glass with its two surfaces, these figures must be doubled, but even then they do not seem large. However, the loss of light increases rapidly when we have several surfaces in series. For optical lens and prism systems, if we assume an average loss of 5 per cent per surface, the presence of six surfaces will result in a 25 per cent loss of light by reflection, cutting the transmission of the system to 75 per cent.

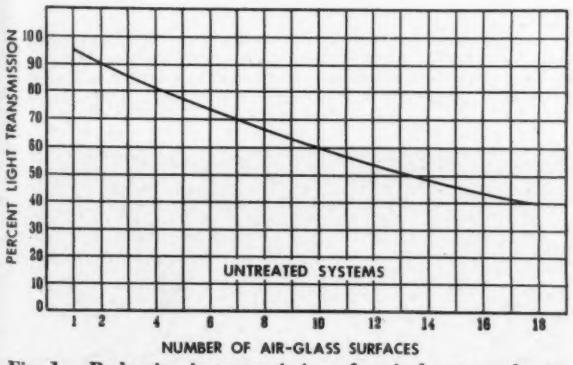


Fig. 1. Reduction in transmission of optical systems due to a 5 per cent loss of light by reflection at each air-to-glass surface of lenses or prisms.

Fig. 1 shows the reduction in transmission caused by reflection losses in optical systems with varying numbers of air-to-glass surfaces.

The method used to reduce the reflection losses from a glass surface is rather simple in principle. It consists of putting on a new surface.

When light strikes a plate of glass, it is slowed up and a portion of the energy fails to penetrate the surface. The surface of the glass acts like a "bump," and in passing over it some of the energy of the light beam is jarred loose and goes to form a reflected beam. The greater the "bump," that is, the higher the index of the glass, the greater is the amount of light jarred off the original beam. Now it seems plausible to try smoothing out this refractive index bump by letting the light penetration take place in steps. Over the surface of the glass plate we put a layer of material of lower index. Then the initial loss at the new surface will be lower than if the light struck the bare surface of the original plate directly, because the index of the new surface is smaller. Of course, we have added a new reflecting surface—the inner-face between the surface layer and the plate—but it turns out that the combined light losses at the two surfaces is less than the light loss by one reflection at the bare surface of the plate. One may easily check this assertion by use of the well-known formulae for computing the fractional amount of light lost by reflection at the two surfaces in question:

$$R_{AF} = \left(\frac{n_F - 1}{n_F + 1} \right)^2 \text{ and } R_{FG} = \left(\frac{n_G - n_F}{n_G + n_F} \right)^2$$

where R_{AF} and R_{FG} are the reflectances at the air-to-film and the film-to-glass surfaces resp., and 1, n_F, n_G are the indices of refraction of air, of the film, and of the glass.

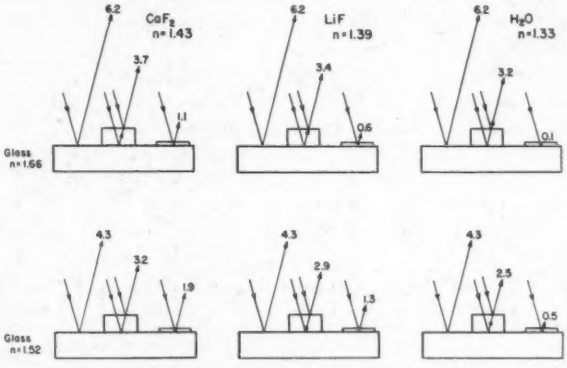


Fig. 2. Reduction of reflection loss with thick and thin (quarter wave) surface layers. Numbers give percentage reflectance.

We can, in fact, cut down the reflection losses by 50 per cent with the proper choice of the index of refraction of the surface layer.

Fig. 2 illustrates the reduction in reflection losses which can be effected with surface layers. Thick and thin layers of different substances are shown in contact with plates of two different kinds of glass, indices 1.52 and 1.66. The surface layers are of fluorite (CaF_2) and lithium fluoride (LiF) and water (H_2O). The numbers on the arrows of each combination give the total percentage of light reflected, that is, the sum of the energy in the beam from the front surface plus that from the inner face. The water layers show the smallest amount of reflected light. It can be proved that minimum reflectance is obtained with either thick or thin layers if the index of refraction of the layer material is equal to the square root of the index of the glass to which it is applied. Of the three surface layer indices shown, that of water (1.33) most nearly satisfies this condition when

it is on the 1.66 glass. The reflectance of this combination when the water film is thick is about half the reflectance of the bare glass. One transmission film material widely used, sodium aluminum fluoride, has an index very near that of water. Since the effectiveness of the film material depends only on the index of the film and that of the glass, it can be employed to lower the reflectance of the glass by practically the same amount as the water in our example.

On ordinary glass (index 1.52) a thick layer of water reduces the reflection loss from 4.3 per cent to 2.5 per cent. We have, no doubt, all enjoyed the benefit of the resulting 2 per cent gain in transmission, although perhaps unknowingly. When driving in the rain, namely, with the windshield wiper spreading a layer of water over the windshield, the latter actually becomes more "transparent" and lets 2 per cent more light through. Although it is true that the slight increase in brightness of the road will hardly be apparent to the driver, the effect of water in reducing the reflectance is often apparent on the windshield of an oncoming car, especially if there are dry portions. Compared with these dry parts, the wet patches appear dark because less light is reflected from them.

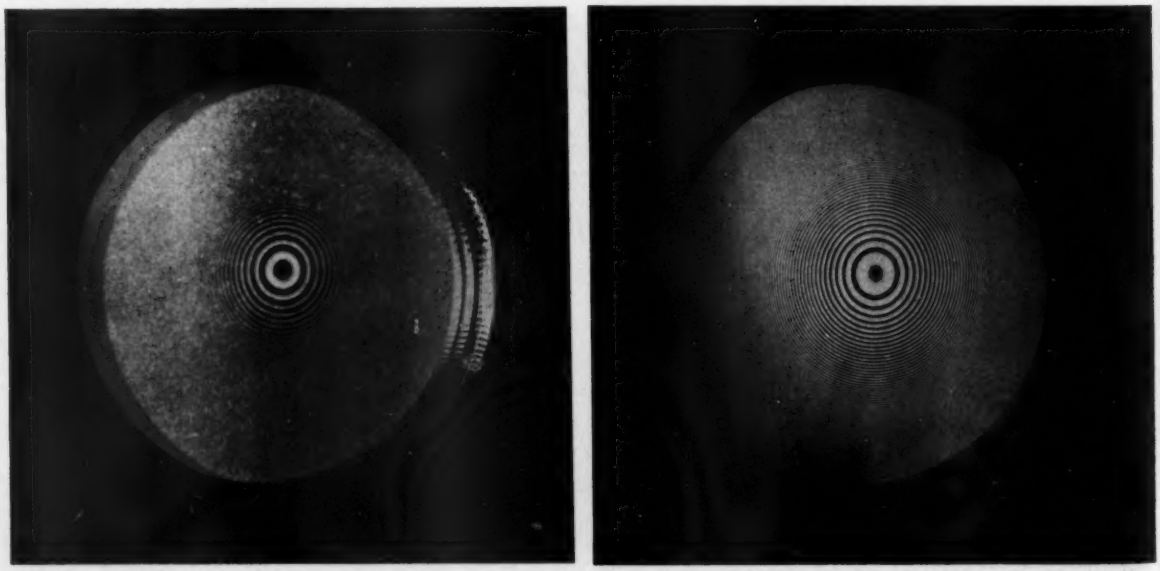
Noteworthy in Fig. 2 is the much greater effectiveness of the thin films. With them the reflected light can be reduced to an almost negligible loss, that is, the transmission of a plate of glass can be raised to nearly 100 per cent. This brings up the question of how thick the thin films should be.

Reference was made above to the fact that the optimum *index* of the surface layer is the square root of the index of the glass. There is also an optimum *thickness* for the layer, or rather, film, since this thickness comes out to be only 4 millionths of an inch. Let us start with a thick reflection-reducing surface layer on glass. It may be a millimeter thick or a hundredth of a millimeter, it makes no great difference. We would find that the light reflected from it is not changed in color. The reflected light would simply not be as brilliant from the portion of the glass with the surface layer as from the bare glass. But if we continuously decrease the thickness, we find that around a thousandth of a millimeter the reflected light would become tinged with color. The colors change as the thickness is reduced and become at the same time more saturated. We are entering the region of thickness dimensions comparable with the dimensions of the light waves themselves, and the wave nature of light puts in an appearance. The colors are due to the interference of the light reflected from the front surface of the film with the light reflected from the film-to-glass inner face. The interference phenomena do not start suddenly at some particular thickness, they merely become observable to the unaided eye in the very thin films. Interference takes place in the thick films also, but here it cannot be observed under ordinary conditions.

Interference effects are not uncommon in our everyday life. The colors in soap bubbles, the colors of oil spots on the wet pavement, and the colors appearing in laminated safety glass which has split open are all due to light interference between two beams from the opposite sides of a thin film.

An easy way to obtain an air film is to press a convex glass surface against a flat glass surface—such as a lens against a flat plate. The resulting interference fringes are circular because of the circular symmetry of the air wedge, and they are known by the name of "Newton's Rings." These rings can sometimes be seen between the components of an uncemented doublet lens, such as a telescope objective, where the elements have come into contact. Fig. 3 shows a picture of Newton's Rings between two glass plates taken (a) with white light, and (b) with monochromatic light. With the former the interference is visible only where the film is thinnest

Figs. 3a and 3b. Interference or "Newton's Rings" formed in the air film between a flat and a convex glass surface photographed in reflected white light (left) and monochromatic light at the right. A new ring appears for every increase of the double air film thickness by a whole wavelength. The equivalent air film thickness at the center where the surfaces are in contact is not zero, but is a half wavelength due to the phase shift suffered by the light beam at the lower surface. Accordingly the center is black.



toward the center of the ring system, whereas in light of one wavelength the interference is visible out to the very edge of the plates where the film is thickest (about 0.02 mm in this case). These pictures were taken in reflected light, but the rings can also be seen in transmitted light.

The most prominent characteristic of the rings when viewed by white light is their color, but this color display tends to direct attention away from the fundamental thing that is occurring, namely, the variation in reflecting power of the air film with its thickness. If we look at a set of Newton's Rings in monochromatic light (Fig. 3b) as by using a red filter, we simply see alternate light and dark rings. In other words, the air film reflects light at certain thicknesses and at others it does not. By the same token we find in looking through the rings that they represent regions of high and low transparency. The enhanced transparency of the alternate rings is obtained at the expense of a decreased reflectivity of the air film at these point. At positions of maximum transparency, the reflectivity of the air film, that is, of the combination of the two glass surfaces, is zero.

The explanation of the formation of the rings by interference is simple and is no doubt familiar to us all. It is vital to an understanding of the action of our anti-reflection films. Under proper conditions interference can take place between two beams of light because of their wave nature. Two waves of equal wave length with a definite phase relation between them can add up to zero on the one hand or to an augmented wave on the other, with a continuous variation between, depending on the phase relation, that is, on how much one wave is displaced with respect to the other. This addition of two waves is shown in Fig. 4.

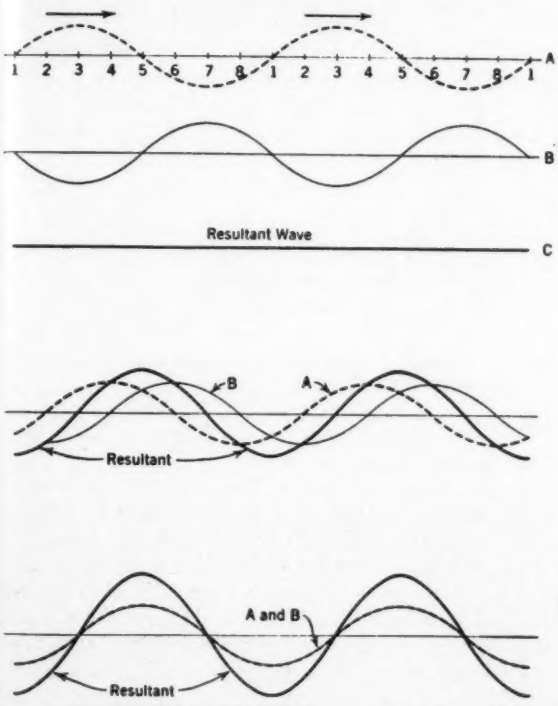


Fig. 4. Addition of two waves A and B of equal amplitude to form a resultant wave C. The amplitude of C increases from zero, when A and B are out of phase, to a maximum when they are in phase.

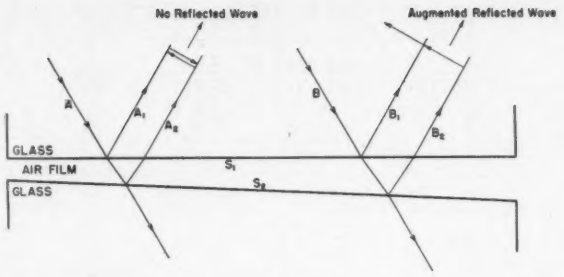


Fig. 5. Diagram illustrating interference at an air film between two glass plates. Beams A_1 and A_2 reflected from the film surfaces S_1 and S_2 are a half wavelength out of phase and no resultant reflected beam is created. Where the film thickness between S_1 and S_2 is greater by a quarter wavelength, the reflected beams, B_1 and B_2, are in phase and an intensified reflected beam results.

In the reflected light from our air film, the two beams which interfere are those reflected from the two surfaces of the air film as is shown in Fig. 5.

The phase relation or displacement between the two intermingling reflected rays depends upon how much farther the second beam has to travel than the first before the two intermingle above the film. Namely, the second beam has had to traverse the air film twice before it meets the first beam again. If the equivalent double film thickness is just a half wavelength, the two beams meet a half wave out of phase, and cancel if the two amplitudes are equal (Fig. 4) as they are if the two pieces of glass have the same index of refraction. On the other hand, if the path difference is a whole wavelength, the two beams meet in phase and an augmented reflected wave results. Since the energy of the reflected beam is tapped from the incident beam, the air film will show a decreased transparency in this second case, whereas when the reflected beam is quenched the transmission becomes 100 per cent.

If one of the dark interference bands in the air film were widened out to cover the whole surface of the glass, by making the air film of uniform and correct thickness, instead of being a wedge, then we would have an anti-reflection film, but it would hardly have any practical value. We have to make our films of something more tangible than thin air. Now actually the most important parts of the film are its two surfaces. Their presence gives us the two reflected beams to interfere, and it does not make a great deal of difference, optically, whether the solid material is outside the film as with the air film; or inside the film as with an anti-reflection film. One might say that the film merely serves to hold the surfaces apart at the correct distance.

There are several interesting ways of providing a piece of glass with a solid film which will have anti-reflection properties, but which cannot be described here for lack of space.

For best optical results, the requirements which a transmission film must meet are:

(a) the optical thickness of the film should be a quarter wavelength.

(b) the index of refraction of the film should be equal to the square root of the index of refraction of the glass to which it is applied.

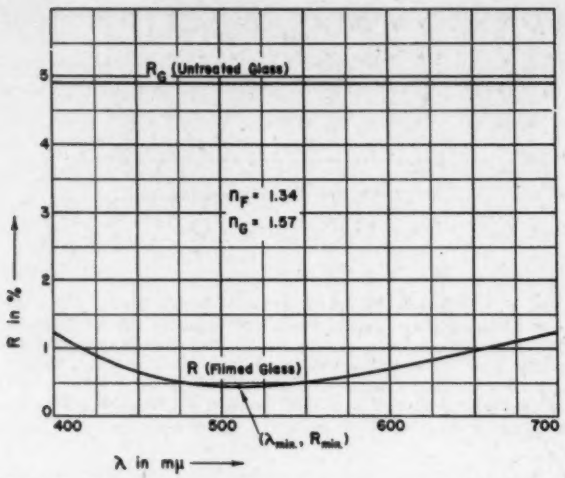


Fig. 6. Spectrophotometric reflectance curve of a filmed glass surface.

Requirement (a) can always be met, and the thickness of the film is easily controlled. Requirement (b) is difficult to realize exactly, simply because Nature did not make many materials with sufficiently low indices for our purpose. However, in practice considerable deviation of the film index from its optimum value is allowable without affecting the efficiency of the films too seriously. Thus even LiF and CaF_2 with indices 1.39 and 1.43 make fairly good anti-reflection films on glass of index 1.66, although the optimum film index here is 1.29, the square root of 1.66.

When the light reflected from a filmed surface is measured in a spectrophotometer, we obtain a curve like that of Fig. 6. The film reflectance curve is not a straight line, since the film is a quarter wavelength thick only for one particular wavelength. At this point, the reflectance is a minimum (the transmission accordingly being a maximum) and it rises slowly toward longer and shorter wavelengths. The reflectance does not go to zero in this example because the index requirement (b) is not satisfied. For a glass index 1.57 a film index of 1.25 would be necessary for zero reflectance at λmin.

A coated lens appears colored in reflected light, and Fig. 6 shows why. The film reflects, in this example, somewhat more in the violet and the red than in the blue-green, where it was designed to have its maximum efficiency. The violet plus red excess results in a magenta, and the light reflected from the surface is of this hue. Any shift of the wavelength corresponding to the exact quarter wave thickness will result in a differently colored film and in practice transmission films may have quite a range of colors.

The light passing through the lens becomes tinted in the complementary hue, but the effect is so weak as to be scarely discernible unless many surfaces are used.

To sum our general statements about reflection-reducing and transmission-increasing layers, we may say: by controlling the index but not the thickness, that is, by using a thick layer, we can cut the reflection loss in half. By controlling both the index and the thickness of the film, the reflection loss can be entirely eliminated, at least for monochromatic light, and practically eliminated for as large a wavelength range as is included in the visual spectrum.

In the practical application of the films to lens systems it is found that benefit is derived not only from the increased amount of light obtained (shown in Fig. 7) but also from the simultaneous decrease in reflected light. In an optical system this latter may be termed "misdirected" light and sometimes it is distinctly annoying because it may give rise to "ghost" images or create a veil of haze light which cuts down the image contrast.

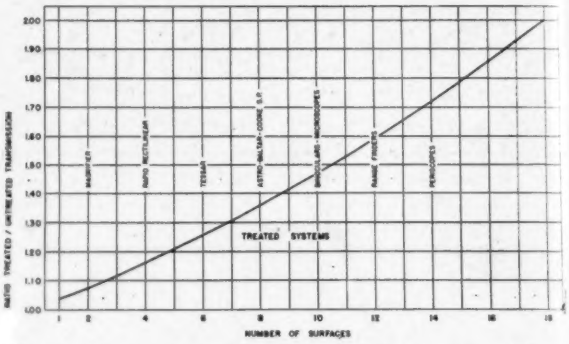


Fig. 7. Increased transmission of optical systems due to use of transmission films.

When anti-reflection films are used here, a "snappier," more "contrasty" image results.

We have been mentioning films a quarter wavelength in thickness. Just how thick such a film is in relation to the glass on which it is deposited can be visualized by the following example: If the glass carrying the film is two millimeters thick, and we magnify it to appear as thick as Mt. Washington is high, then the quarter wave film magnified in the same proportion would be like a 4-inch fall of snow on the mountain top.

THE VALOR CUP

A unique crystal urn, carved with the Great Royal Arms of England and called the Valor Cup, has been presented to the British War Relief Society by Steuben Glass to be sold for that fund. The cup, designed by John M. Gates for Steuben Glass, was made in the Steuben Glass Works at Corning, New York, is a heavy crystal covered urn on a solid foot. It is enlivened by exuberant baroque handles and a finial in the form of a conventionalized crown and ball. The great Royal Arms, committed to the crystal by copper-wheel engraving, dominates the design. It is said that the engraving is the most complicated ever executed by the company.

The British War Relief Society will exhibit the urn throughout the country as a "tacit tribute to the courage of the British people in the present war, soldier, sailor and civilian alike." Later the Valor Cup will be sold for the benefit of air-raid victims.

• The Thirty-first National Conference on Weights and Measures will be held in Washington, D. C., at the Hotel Mayflower, June 3 to June 6. One lecture of special interest to glassmen will be held at the morning session, June 4, titled "The Manufacture of Precision Glassware," by J. J. Moran of the Kimble Glass Company.

G.C.A. MEETING STRESSES DEFENSE

The annual spring meeting of the Glass Container Association was held this year (May 14 to 16) for the first time at Hot Springs, Va. The dominant note of the meeting was defense—its effect on industry in general and on the glass container industry specifically.

Pursuant to a resolution adopted at a previous meeting, the Association had appointed a committee to survey the industry and formulate a program. Inevitably, the mold and machine shop facilities of member companies were nominated for first consideration. It was found that these facilities were suitable for producing small machine parts, gauges and small tools needed by concerns employed on defense contracts. Parenthetically, three glass companies are already devoting a substantial part of their machine shop output to this work.

The Association considers after investigation that its contributions to defense will be most effective if carried out under the York plan. This plan involves the pooling of small company facilities on a sub-contracting basis. A survey shows that the industry has in use over 1500 machine tools, with approximately 1800 operators. It has a substantial number of machine hours per day available, but the skilled operators are working slightly over a forty-hour per week average. Curtailment of some of the normal work of these departments must be effected, obviously, and one of the first such changes must come from limitations in the number of new designs. It is also evident that some 800 or 900 additional machinists would be needed if the equipment were to be operated on a 24-hour basis. The whole situation seemed to call for the services of a coordinator, and the Association appointed Mr. C. P. Overmyer of the Overmyer Mold Company to this position. The fact that the glass container industry's facilities could really become a factor in the defense program is indicated by the experience of Canada. Here, 65 per cent of glass making machine tool facilities have been commandeered by the National Machine Tool Comptroller.

That this whole subject of national defense is far from being of mere academic interest to the glass container industry was to be inferred from the remarks of Colonel H. M. Reedall, who spoke informally to the meeting during the course of its opening session. Reading between the lines of Colonel Reedall's address, it was evident that the industry soon would be making tools, jigs, dies, etc., for armament purposes—and in a big way.

The G.C.A. crowd forgets the defense needs as they are treated to a steak roast by "Chats" Walsh at "The Patch". Here glassmen and their wives are gathering for the preliminaries. Mr. R. F. Sherwood was *The Glass Industry's* photographer.

Roy Blunt (right) of Buck Glass Co. was chief bartender and mixed mint juleps for the thirsty glassmen. He was ably assisted.

Statistically, G.C.A. considers the industry to be in excellent shape. As the monthly statistics published by THE GLASS INDUSTRY reveal, container shipments have been running about 18½ per cent ahead of 1940, which was an all-time high. Possibilities for continued expansion seem favorable in all lines. Productive capacity of the industry has increased in spite of fairly constant melting areas, due to the increasing production of lightweight containers which permit of greater grossages per ton of glass. A high level of production undoubtedly will be maintained throughout the war period, though pessimists are already warning against a post-war recession when competitive foreign imports are expected in large volume.

Research and promotional activities have been curtailed during 1941, largely as a result of the Toledo situation. However, the Glass Kitchen project will be continued aggressively. The industry has definitely made progress in the food container field, and has established as a factor of successful promotion the need to train retailers in the display of glass-packed products. In the beer field, promotional activities for the remainder of this year will feature the new split sizes, 7 and 8 oz. Sixty-six brewers had adopted one of these two sizes as of April 1, and demands from military camps should bring about a further increase in their popularity. Incidentally, the preference for glass against tin in Army Post Exchanges is in about the same proportion as in the ordinary packaged beer trade—preponderantly for glass.

Now that the quartermaster corps of the Army is feeding some 800,000 men at 400 different posts—a number that should be doubled by mid-summer—the daily food buying of the Army will amount to some $750,000. Army specifications in the past have worked a hardship on glass packed products in many ways, particularly in the matter of container capacities. If the system should be changed so that foods will be bought on a per pound basis rather than on a unit container basis, glass would have an equal opportunity with tin. We may expect to see a sizeable

Host Walsh in a cloud of smoke manages to spare a glance for the photographer while cooking the steaks for the hundred or so guests.

demand for the 2 lb. Tabl-Serv preserve jar, and for a similar peanut butter jar just developed. It has also been determined that there is need for a 2 lb. apple butter jar.

The fellowship at Massachusetts State College had provided excellent ammunition in the controversial matter of vitamin C retention. The findings show that the effect of light on the vitamin C content of glass packed products is practically negligible; other factors, the variety of the fruit, the growing season, the storage temperature, exert influences that are infinitely greater.

Other matters reported at the G.C.A. Convention included the misrepresentation of plastic products as glass; damage claims involving broken bottles; and technical research. Attention has already been called in THE GLASS INDUSTRY to the suit which the Federal Trade Commission has entered against "Elastiglass."

Damage claims for accidents arising from broken bottles is on the increase. Formerly this was largely confined to pressure ware; but lately it has spread to other lines. And this despite the fact that all recent cases have been successfully defended. It is felt that the misuse of lightweight containers may be in a measure responsible; as, for instance, the use of beer bottles for carbonated beverages.

At the Preston Laboratories, a great deal of work has been done on the subject of cords and much of this has been reported in papers read before the American Ceramic Society. Dr. Ghering, Dr. Turnbull, and an assistant have spent most of their time on this; though since February, Dr. Ghering has had to work mostly on broken bottle cases.

Dr. Ghering and Dr. Turnbull presented a paper last April (*see* GLASS INDUSTRY, May 1941) in which was described an improved method for separating cords according to density differences and a method of determining the amounts of cord of various densities by use of the imamounts; i.e., the density distribution curve, whether the cord is foreign material (refractories) or is of batch origin.

The laboratory technique is now advanced to the point where its use together with the information concerning the batch and tank operation that the plant operator will have in any systematically operated and controlled plant, makes it possible to diagnose the cause of the cordy condition. One unique and complete analysis of a cordy condition has been made for one company by close cooperation of a technical production man of that company with the Preston laboratory. Having found the cause, this cord was eliminated. Other cords have been analyzed and reports submitted to five other companies.

The research is continuing and is being extended to include a general study of the melting process, particularly the relative rates of diffusion or mixing of the various batch ingredients. A new electric melting furnace and equipment have been installed for this work with which cords will be made artificially under controlled conditions and the results correlated with regular plant operation.

The G.C.A. Standard Testing Procedure Committee has revised its manual to include a special thermal shock test that will insure the fit of the fusible frit color on the glass. No serious complaints of breakage arising from inferior colors have been brought to the attention of this laboratory within the last six months. Several samples of bottles have been tested, but it appears that the color suppliers, as of 1941, are not having difficulty in supplying color that matches the expansion of the glass. However, there is still danger and it is still necessary for the bottle manufacturer to make his own tests.

Important work has been done in standardizing beer bottles. The matter was brought to an issue about a year ago when a committee of The Brewers Association requested a conference with The Glass Container Association. The brewers were finding that there were so many styles of bottles in existence as to seriously interfere with bottling operations. And as a result of the conference, a joint survey was made and this revealed the existence of 80 different styles of bottles. Many of these were of the same capacity but differed in weight and body specifications. These 80 different sizes and shapes have now been reduced to 22, and a campaign is being organized to the effect the adoption of these standard containers by the glass container and brewing industries.

• Professor George H. Brown, active head of the Ceramic Department of Rutgers University, was tendered a testimonial dinner May 16 in commemoratoin of 25 years as director of ceramics at Rutgers. Professor Brown was presented a large Lenox plaque bearing a reproduction of the Rutgers ceramics building.

Charles Stevenson and J. L. Crawford seem well satisfied as they survey the close of the roast.

CURRENT STATISICAL POSITION OF GLASS

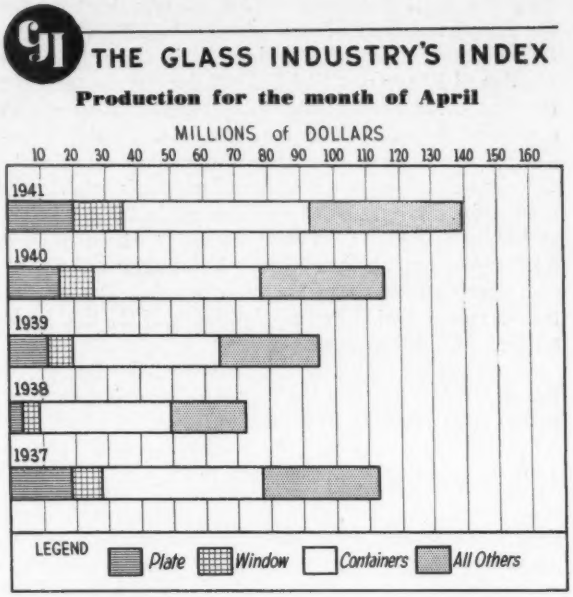
During April a new production record was set by glass manufacturers as employment and payrolls soared to new peaks; exports continued heavy but imports remained at a low volume. According to THE GLASS INDUSTRY's Production Index glass output during April totalled $37,000,000 as compared to $36,000,000 in March and $30,000,000 in April 1940. During the first four months of 1941 production increased 20 per cent over last year's volume to $139,000,000.

Plate glass production during April totalled 18,344,200 square feet according to the Plate Glass Manufacturers of America. This was less than 1 per cent greater than the March total, but was 48 per cent above the April 1940 figure. During the first four months of 1941 production of plate glass totalled 71,624,700 square feet, which indicates that the industry is running at a rate which is 26 per cent greater than last year.

Window glass output during April totalled 1,400,402 boxes which was slightly below the March figure of 1,416,869 boxes. During the first four months of 1941 production amounted to 5,775,000 boxes—30 per cent above last year's level.

Glass container production during April totalled 5,325,470 gross, according to the Glass Container Association of America. This was the largest monthly output in the history of the industry representing an increase of 4 per cent over the high March total, and a gain of 15 per cent when compared with the April 1940 output. During the first 4 months of 1941 glass container production amounted to 19,338,161 gross—10 per cent more than the comparable 1940 figure.

Shipments of glass containers during April totalled 5,573,264 gross—another record total. This was 9 per cent more than in March and exceeded the April 1940 volume by 28 per cent. All types of containers with the exception of pressed food ware moved in larger quantities compared with April of last year, but greatest gains were reported for domestic fruit jars (up 142 per cent), domestic jelly glasses (up 88 per cent), narrow necked food containers (up 36 per cent), beer bottles (up 39 per cent), liquor ware (up 35 per cent), milk



bottles (up 33 per cent), general purpose ware (up 32 per cent); increases ranging from 22 per cent to 25 per cent were reported for the other lines. Total shipments for the first 4 months of 1941 amounted to 19,140,722 gross which was 19 per cent greater than during last year's comparable figure. Here again increases were reported for all lines with the exception of pressed food ware. Domestic fruit jars increased 170 per cent, beer bottles 41 per cent and domestic jelly glasses 53 per cent; other gains ranged from 10 to 28 per cent.

Inventories of glass containers as of April 30, 1941, totalled 9,612,197 gross—6 per cent below the 1940 level. Decreases were reported for all lines with the exception of pressure and non-pressure ware and medicinal and toilet ware.

Miscellaneous glass products manufactured during April had a value of $13,000,000 which was 9 per cent greater than the March total and exceeded April 1940 by 33 per cent.

Production of automatic pressed tumblers during

CURRENT GLASS CONTAINER STATISTICS

(ALL FIGURES ARE IN GROSS)

Types of Ware	*Production*		*Shipments*		*End of Month Stocks*	
	April, 1941	*April, 1940*	*April, 1941*	*April, 1940*	*April, 1941*	*April, 1940*
Food Containers (Narrow neck, wide mouth and pressed)	1,347,368	1,214,497	1,436,463	1,140,107	1,997,240	2,080,939
Pressure and Non-Pressure Ware	493,007	492,597	633,152	510,345	890,324	846,481
Beer Bottles	489,492	319,671	418,267	295,098	867,220	1,075,906
Liquor Ware	815,414	634,636	865,152	643,049	1,440,450	1,442,325
Medicinal and Toilet Ware	1,504,595	1,313,083	1,521,663	1,253,709	3,005,510	3,163,108
General Purpose	388,505	368,206	405,344	306,294	580,174	569,597
Milk Bottles	232,561	195,226	228,640	171,887	294,791	351,230
Fruits and Jellies	23,451	38,636	40,694	17,500	492,959	664,714
All Others	31,077	21,617	23,889	16,960	43,529	39,268
Total Industry	5,325,470	4,598,169	5,573,264	4,354,949	9,612,197	10,233,568

April totalled 3,838,313 gross—a drop of 4 per cent from the April 1940 level. This brought the total for the first 4 months to 1 per cent below 1940's volume. Shipments of this ware during April showed an expansion of 10 per cent to 4,386,800 dozens; the total for the first 4 months of 1941 were 15,456,387 dozens as compared to 14,427,173 dozens last year. Stocks of machine made tumblers as of April 30 amounted to 7,499,451 dozens—3 per cent less than last year's total.

Manufacturers' sales of machine made table, kitchen and household glassware were reported to have totalled 3,921,706 gross, which represented an increase of 43 per cent over last year's comparable month. During the twelve month period ending April 30, 1941, this trade totalled 34,682,029 dozens.

According to a preliminary release of the Bureau of Census, twelve illuminating glassware manufacturers reported sales totalling $727,000 during April which was 7 per cent more than their April 1940 business but was 3 per cent under the March 1941 total.

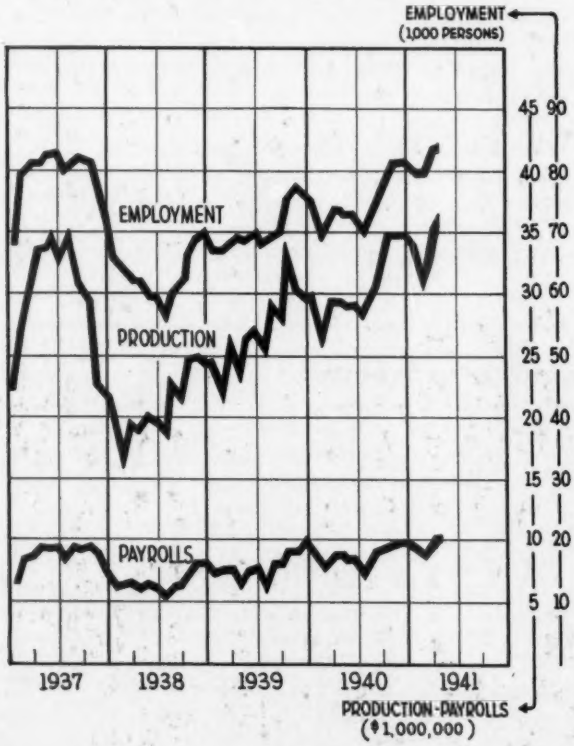
Employment and Payrolls: Approximately 84,800 persons were employed in the glass industry during April; this was even greater than the March record of 83,800. In April, 1940, 73,600 workers were employed in the manufacture of glass and glass products.

Payrolls in the glass industry during April hit a new peak also, with total wages estimated at $10,500,000. During the first 4 months of 1941 glass manufacturers paid their employees $39,700,000 as compared to $33,100,000 last year.

The compilation of foreign trade statistics has been so delayed by the pressure of special National Defense compilations that they were not ready for release as this issue of THE GLASS INDUSTRY went to press. However, it is expected that arrangements can be made in the future to provide our readers with this pertinent data.

THE GLASS INDUSTRY'S INDEX

Monthly Trends Through April, 1941



ARGUMENTS BEGIN IN L.O.F. CASE

Oral arguments in the Celluloid Corp. patent infringement case against the Libbey-Owens-Ford Glass Co. were heard May 26 by Judge Leslie R. Darr, federal district judge of Nashville, Tenn., who is assisting Judge Frank L. Kloeb with the heavy federal docket at Toledo.

The Celluloid Corp. maintains that the patent being used by the L.-O.-F. for the manufacture of laminated glass is an infringement on patents it holds.

After hearing the case for several months Amos L. Conn, special master, wrote a finding in favor of the Toledo concern. This was studied by Judge Darr. Exceptions to the finding were then filed by the Celluloid Corp., and arguments on the exceptions have begun.

•H. D. Risdon, manager of the Roe-James Glass Company, St. Paul, Minn., died early in April, ending a career of more than 50 years in the glass jobbing business.

BOMBS DESTROY GLASS STRUCTURE

The rigorous censnorship exercised on all communications from the Netherlands, lends special interest to a letter recently received by THE GLASS INDUSTRY from Dr. Jar. Polivka who for more than a year has been connected with the University of California at Berkeley, California, as Research Associate in the Engineering Materials Laboratory. Dr. Polivka writes that the tremendous new edifice of the Corn Exchange at Rotterdam, the largest glass-concrete structure in the world, is known to have been partially demolished by German bombs.

Dr. Polivka was sent to the United States by the Czech Government in 1938 to supervise the erection of the Czechoslovak Pavilion at the World's Fair. It had been planned to erect a magnificent glass building at the Fair, surpassing the featured Pavilion at the Paris Exposition. To this end, special glass units had been made specially for the purpose, including large hollow block of amber color that had special light diffusing and heat insulating properties. With the invasion of the Sudetenland, the glass as well as the factories in which it was made, was confiscated by the Germans.

• Mr. D. P. Forbes, Gunite Foundries Corp., Rockford, Ill., was elected vice president of the American Foundrymen's Association at their annual business meeting held in New York May 14 at the Pennsylvania Hotel.

FOR SALE

1 Only Size 4 Focht Gas Kiln - - $200.00
2 Only Size 3 Focht Gas Kiln - - $125.00 each
Muffled Decorating Kilns—F.O.B. Dunbar, West Virginia.

Dunbar Glass Corporation

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During April

Compositions

The obstructions to normal communication with warring countries is reported to be making it very difficult for foreign inventors to file and pursue patent applications in this country. To date this has probably had little effect on the number of patents granted since most patents were filed before the outbreak of war. In this class are patents 2,240,327 issued to Wm. Elenbaas and Gottfried B. Jonas of Eindhoven, Netherlands, and 2,240,352 to Rudolph Schmidt, Weisswasser, Oberlausitz, and Walter Hänlein, Berlin-Spandau, Germany. The Elenbass-Jonas patent reveals that a glass which is chemically stable in the presence of hot ionized cadmium vapor and is suitable for making cadmium vapor discharge lamps may contain 78 per cent SiO_2, 12 per cent Al_2O_3 and 10 per cent CaO. This composition is said to transmit ultraviolet rays satisfactorily. The Schmidt-Hänlein patent assigned to General Electric Co. is also concerned with glass for a gaseous metal discharge lamp, and particularly for the inner layer of a two layer tube in which the outer layer is a soft soda glass. The inventors state that when the inner layer is made of a boro-silicate glass containing 10 to 25 per cent silica, the glass assumes a brownish tint when the tube is operated at about 300° C. When the boric oxide has been raised to 60 per cent and, the silica dropped to 4 to 9 per cent, a bluish-gray veil or discoloration appears during the operation of the tube. This is thought to be due to the hygroscopic nature of such glasses and to the resulting absorption of the traces of moisture which find their way into the tubes from the gas flame contacting them during manufacture. Non-hygroscopic glasses which Schmidt and Hänlein have patented for use in gas discharge lamps have the following range of composition:

	Per cent
Silica	4 to 9
Boric oxide	20 to 30
Alumina	20 to 30
Barium oxide	30 to 40
Sodium and postassium oxides	6 to 10

Combinations of selenium and gold halide (for example chloride or bromide) for producing permanent red colors were patented by Harry A. Truby, New Kensington, Pa. (2,237,042 assigned to Pittsburgh Plate Glass Co.). One of his formulae for an opaque red glass calls for 0.00173 per cent gold chloride and 0.000216 per cent selenium.

Fluorescent screen compositions and their applications are detailed in patents 2,238,026 to Wm. R. Moore, Emporium, Pa. of Hygrade Sylvania Corp. and 2,237,123 to M. C. Teves, Eindhoven, Netherlands (Radio Corp. of America).

Testing

It is often difficult to determine by inspection whether a glass plate is homogeneous or built up of a series of laminations. Allan C. Waine and Fazul Din of Birmingham, England in patent 2,239,263 (Triplex Safety Glass Co. Ltd.) describe an apparatus which may be applied to windshields and other glass products to settle this question. Fig. 1 shows only the working principle of the apparatus they have designed. First a section of black gummed paper is pressed into close contact with one side of the plate. Then a monochromatic beam of light is directed through a prism and obliquely into the other side of the plate; the beam is reflected from each glass surface again through the prism and through a vertical eyepiece. If the plate is non-laminated the operator will observe two dots of light, one from the top and one from the bottom reflecting surfaces. If the sheet is laminated other dots will appear. There will be two separate but overlapping dots produced by the two sides of the plastic interlayer.

Furnaces

The movement of molten glass in the forehearth, always a fertile field for inventors, is again the subject of a Hartford Empire patent, 2,238,800 granted to Donald W. Mueller of West Hartford, Conn. He provides banks of vertical rotating rods which are imparted also with movement laterally across the flowing glass stream. These provide a "wringer-like" or squeezing action to reduce cords and stria.

A number of suggestions have been made for the reduction of horizontal joints in flux block wall construction since it has been shown that gases entering the brickwork at these points tend to drill upwards and in this manner to enlarge the joint. Paul G. Willetts of West Hartford has just proposed in patent 2,240,361 (Hartford Empire) a glass furnace construction in which horizontal joints below the metal line are entirely eliminated. As shown by Fig. 2 this is accomplished by means of blocks of special shape laid with a sloping wall. The patent does not broadly cover this feature which may not by itself be novel, but introduces also features of breastwall construction which include water cooling at a point just above the metal line.

Feeding, Forming and Shaping

Elmer H. Haux and Wm. O. Lytle of Pittsburgh Plate Glass Co. entered the list of April patentees with patents

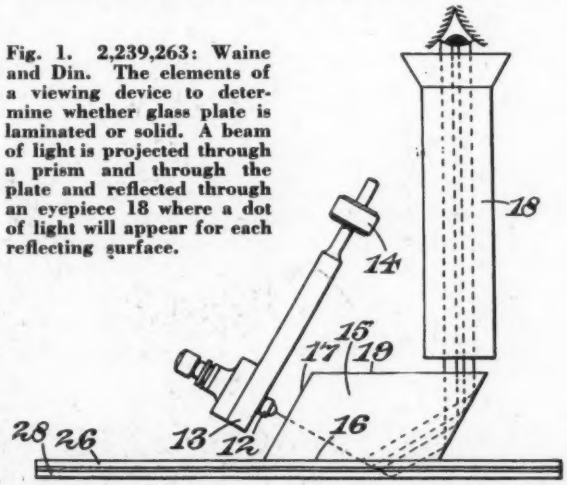


Fig. 1. 2,239,263: Waine and Din. The elements of a viewing device to determine whether glass plate is laminated or solid. A beam of light is projected through a prism and through the plate and reflected through an eyepiece 18 where a dot of light will appear for each reflecting surface.

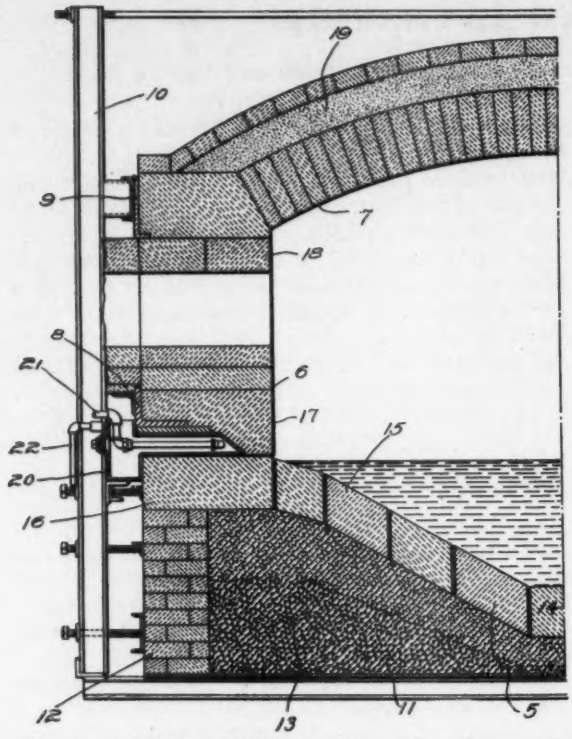


Fig. 2. 2,240,361: Willetts. In a glass furnace the breast-wall blocks 17 are water cooled and the flux blocks are laid in a sloping wall to avoid the vulnerability of horizontal joints.

2,237,032 and 2,237,037 for cellular glass. In the acoustic art one of the favorite theses states that the sound absorbing cells or pores need to communicate with one another to provide the most efficient sound damping. Mr. Haux proposes to heat cellular glass to 300° F. and then to cool it rapidly enough to fracture the cell walls so that the cells will join each other. Mr. Lytle provides a new means of introducing cellularity into glass. He heats pulverized glass mixed with water under pressure, so as to melt the glass with entrapped steam; while the glass is still viscuous, pressure is released, and cells are formed in the glass by the expansion of the entrapped steam.

Fig. 3 details an altogether new means of glass making in which the individual glass forming compounds are used in the form of gases which are carried into an oxygen flame where they are decomposed and vitrified. By directing such a blast at a lead-in wire of a quartz lamp the glass is built up in place on the wire. In making boron-alumina-silica glasses the gaseous glass constituents may be boron fluoride gas, aluminum chloride, and silicon tetrachloride. These methods yielded glasses in the following composition ranges: 78 to 89 per cent SiO_2, 10 to 31 per cent B_2O_3, and 1.2 to 11.4 per cent Al_2O_3. Since each of the gaseous glass constituents is supplied from a separate valve-controlled container their relative proportions can be varied. This new glass making method is the invention of Robt. H. Dalton and Martin E. Nordberg, Corning, N. Y. (2,239,551, Corning Glass Works).

David F. Sawyer of Rock Springs, Wyo., describes in patent 2,239,055 a means of bending tubing into spiral form over a hand turned grooved mandrel.

Thomas F. Pearson of Pontefract, England, assigned to Crown Cork & Seal Co. his patent 2,238,283 for a mechanism for shearing a suction mold charge.

Walter K. Berthold, Rockville, and Henry W. Ingle, Windsor, Conn. (Hartford Empire Co.), received patent 2,238,803 for an apparatus and method of forming narrow neck glass articles on a paste mold machine. The method follows normal narrow neck practice for producing the blank, but then forms the final shape in a paste mold where the blank is rotated during the blowing to final form. These steps as applied to the manufacture of the upper glass member of a glass coffee maker are illustrated in Fig. 4.

Patent 2,240,324 granted to Samuel D. Bert of Washington, Pa., and assigned in part to Maurice A. Yorkin and James D. Martin of Washington, is concerned with improvements in the Geneva type of glass machine driving device.

Henry H. Blau's latest contribution to the Corning Glass group of patents on hollow building blocks is 2,238,153 in which he proposes to fill the blocks with CO_2, SO_2, N_2O or other gasses from a group defined as having a "molal heat capacity of at least 8." The preferred gases have high specific heats which is said to minimize their tendency to cause the blocks to bulge or blow out during sealing or annealing. Another specification on the gas used is that it shall not condense at

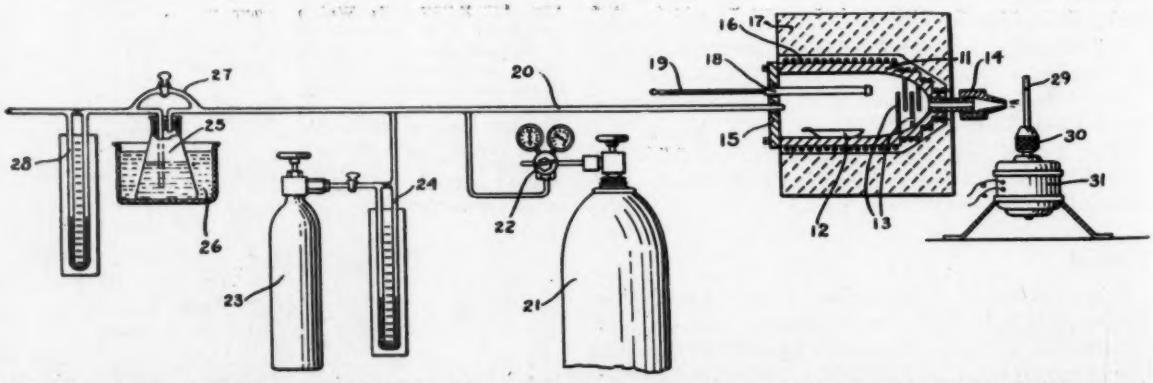


Fig. 3. 2,239,551: Dalton and Nordberg. Glass constituents in gas form are decomposed and vitrified in oxygen blast 14, and deposited on a lead-in wire 29. Silcon tetrachloride from flask 25, boron fluoride gas 23, and aluminum chloride in a boat 12 are entrained into the oxygen blast to form a silica-boron-alumina glass.

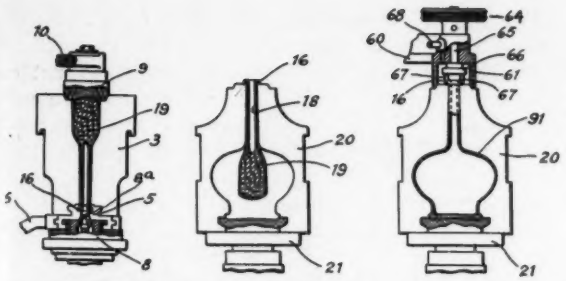


Fig. 4. 2,238,803: Berthold and Ingle. In an adoption of narrow neck practice the final shaping is accomplished in a paste mold where the blank is rotated during the blow. The parison formed in the blank at the left is inverted into the blow mold where enough heat is absorbed from the long neck to allow its rotation during the final blowing steps.

temperatures above —15 degrees F. which is about the lowest temperature at which the blocks would be used in service.

A particular advantage claimed for Blau's process arises from the fact that the gas, supplied in liquid or solid form, volatilizes rapidly and tends to sweep all of the air and moisture from the blocks just before they are sealed. This action is said to prevent weathering of the glass surface and its fogging by condensation.

Harold R. Schutz of Toledo (Libbey Glass Co.), received patent 2,239,627 for improvements in the methods and apparatus for burning off the moile from beaded edged tumbler. During most of the severing operation the moile and tumbler are of course rotated together but at a stage essentially coinciding with the completion of the severing operation they are rotated in opposite directions or at different speeds. This is only one of the novel features of the process.

A method of applying the luminescent coating to the inside of tubing for electric lamps while they are being formed and are still molten, is described in patent 2,237,-754 assigned by Leonard J. Davies of Rugby, England, to General Electric Co. The coating is blown into the tube as a powder.

Decoration

A screen stenciling method of placing trade identification marks on test tubes and the like is described in patent 2,237,168 granted to John C. Smith of Beaver, Pa. (Solar Laboratories Co.)

Patent 2,237,058 which issued to Wm. H. Nutt of Beverly, Mass., is concerned with apparatus for handling such ware as milk bottles while they are being decorated.

Decoration of glass articles by a stencilling process wherein the color is forced onto the article by suction or pressure from a pervious screen is a feature of patent 2,239,619 issued to John B. Murgatroyd and John G. Gregory of Greenford, England. This patent was assigned to Owen-Illinois Glass Co.

Bernard Long of Paris received a patent for mirrors and other metal coated articles made of tempered glass. This is patent 2,236,911 assigned to Societe Anonyme des Manufactures des Glaces & Produits Chimiques de Saint-Gobain, Chauny & Cirey, Paris, France.

Alexander G. Gurwood of Pittsburgh (Pittsburgh Plate Glass Co.) received two patents for mirror producing operations. These are 2,239,519 and 2,239,520. The first covers a reducing solution for silvering which consists of a reducing sugar, an aliphatic alcohol and an organic acid of the acetic, citric or tartaric type. The second patent concerns a decorative mirror with novel means of producing designs in subrelief.

The art of applying semi-transparent films to glass surfaces has developed to an important extent as a result of the usefulness of such products in a number of fields including color photography. The camera may employ a mirror which must reflect or exclude and transmit different colors of light in predetermined proportions. For example where a coating was needed which would reflect red and blue light readily but would transmit green light, a combination coating of aluminum and copper has been utilized. Patent 2,239,452 describes the method by which Robley C. Williams of Ann Arbor, Mich., and John E. Ruedy of Haddon Heights, N. J., have been able to apply a metallic coating of known characteristics. They utilize thermal evaporation in a vacuum. A concentrated beam of light is passed through a dummy glass article during deposition of the coating, and a light measuring device indicates the precise instant when the desired degree of transparency has been attained.

Clarence Birdseye and Pincus Deren, of Gloucester, Mass., assigned to Birdseye Electric Corp. their patent

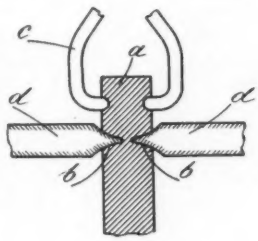


Fig. 5. 2,237,982: Ferlito. To avoid tool marks on sheets suspended vertically for tempering, a breaking strip "a" is produced when hot or cold by grinding. Removal of this strip after tempering also removes the hanger marks. The cutting tools "d, d" are shown in action.

2,237,328 for a process of metal coating the inside of glass bulbs by locally heating a metal charge within the sealed bulb to cause it to volatilize.

Miscellaneous Processes

Details of metal to glass seals are disclosed in patents 2,239,423 to Albert W. Hull, Schenectady (General Electric) and 2,238,599 to John H. Ramage of Bloomfield, N. J. (Westinghouse E. & M. Co.). In both instances the seal is made to a high nickel alloy wire.

Patent 2,238,791 to Francis E. Dorsey of Hartford, Conn. (Hartford-Empire), describes an annealing method and lehr of the type making use of the circulation of tunnel gases for aid in temperature control. Toward improving this control Dorsey provides false walls on the sides to close off air conduits from which nozzles blow air transversly across the annealing chamber.

Obren M. Farris of Clarksburg, W. Va. (Hazel Atlas) in patent 2,240,093 was granted claims for an apparatus for handling glass articles to a conveyor. Patent 2,237,-345 to Herman C. Frentzel Jr. and Henry A. Strelow (The Heil Co.) is concerned with conveyor transfer devices.

To accomplish tempering of glass tubing Kenneth Stratton of Corning, N. Y. (Corning Glass Works) has worked out a method which involves rotating the heated

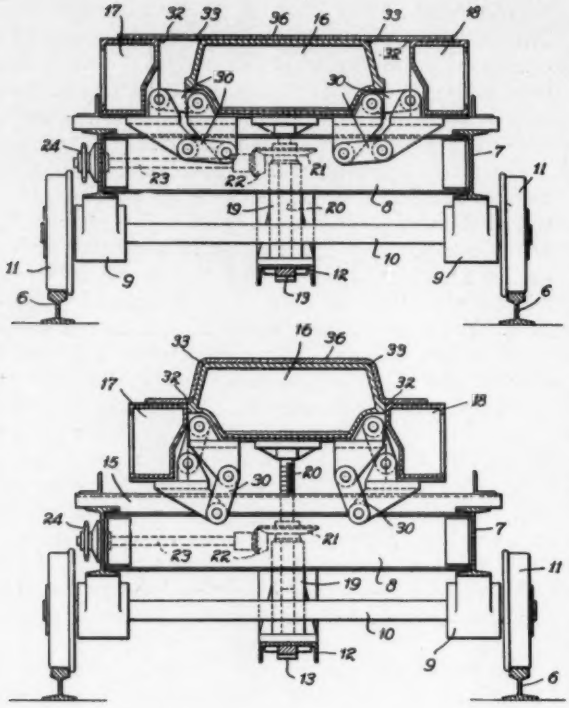


Fig. 6. 2,240,349: Pretson. To form a channel section a flat glass plate is laid on a three section table (16, 17, 18) of which the middle section 16 can be elevated (lower view) and the side tables moved inward, to allow the softened glass to take the desired shape.

tube while a cooling blast is directed simultaneously toward its outside surface and into the two open ends alternately. This is patent 2,239,796.

Plate and Sheet Glass

Two current examples of inventions directed toward the elimination of hanger marks produced on sheets heated for tempering, come from points as widely separated as Pittsburgh and Milan, Italy. These are disclosed in patents 2,239,535 to Gerald Z. Minton and Lloyd V. Black, Tarentum, Pa. (Pittsburgh Plate Glass Co.) and 2,237,982 to Edoardo Ferlito of Milan. Ferlito mentions that while the marks made by tongs or other vertical suspending means may be very slight, that they are highly noticeable if the tempered sheet is used in producing a mirror. He therefore proposes to provide the sheet with a marginal strip by which it is supported, and which is later to be broken away. The general idea is understandable from Fig. 5. Minton and Black support sheets for tempering in a frame which allows them considerable freedom. The bearing elements or supports are rollers at the bottom, adjustable bearing pins at the top which touch only the edge of the sheet, and notched elements at the sides which bear yieldably against the edges and hold the sheet against side play.

Minton and Black were granted a second patent (2,239,546) pertaining to means for bending glass sheets. Light metallic members or wires applied to both sides of a sheet suspended vertically, are tensioned to apply a pressure to the sheet which tends to bend it. When the sheet is heated to the softening point, the wires become automatically effective to bend it to the desired curvature. The principle which can be fully understood only by referring to the patent, is that of supporting the wires from a curved bar in such a way that those bearing on the extremities of the sheet exert more pressure than those near the center and therefore cause bending.

Another Pittsburgh Plate Glass Co. patent 2,239,527 was granted to James W. Kamerer of New Kensington for a multiple laminated glass. For example a 5 ply sheet would have four plastic bonding layers of which the outer two would be a plastic cellulosic material and the two inner layers would be a resin of the vinyl acetate type.

Fig. 6 shows Frank Preston's apparatus of patent 2,240,349 for bending structural glass. The purpose is to form a flanged channel shape from a flat sheet. The process makes use of flat sheets which may retain their original heat or may be reheated for the bending operation. They are placed on a carriage so that they rest on a center table (see drawing), and then extend across a non-supported area to marginal tables 17 and 18. When the sheet is amply softened the center table is elevated as shown in the lower view of Fig. 6 to allow the overhanging portions of the sheet to sag. Simultaneously the marginal tables 17 and 18 are drawn toward the center at such a rate that the distance between the corners 32 and 33 will remain constant. This aids the shaping process and provides the final form.

Glass Wool and Fiber

Fig. 7 shows a fiberizing apparatus described in patent 2,238,204 issued to Wm. J. Woods of Corning, N. Y., and assigned to Owens-Corning Fiberglas Corp. Highly fluid glass flows onto a revolving fluted cone and is blown into fibers by jets placed in rings both within the cone and outside its bottom edge. The fibers fall in matted form.

Another patent obtained by Owens-Corning Fiberglas Corp. was 2,239,722 which issued to George M. Lannan and Frank Vanucci of Newark, Ohio. The subject matter is an apparatus for entwining glass fibers into a continuous smooth strand or sliver.

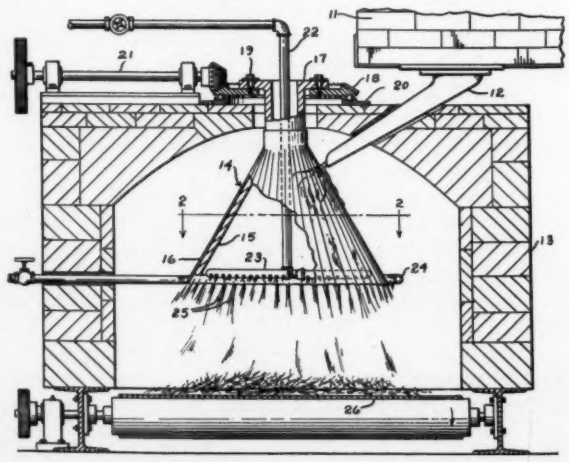
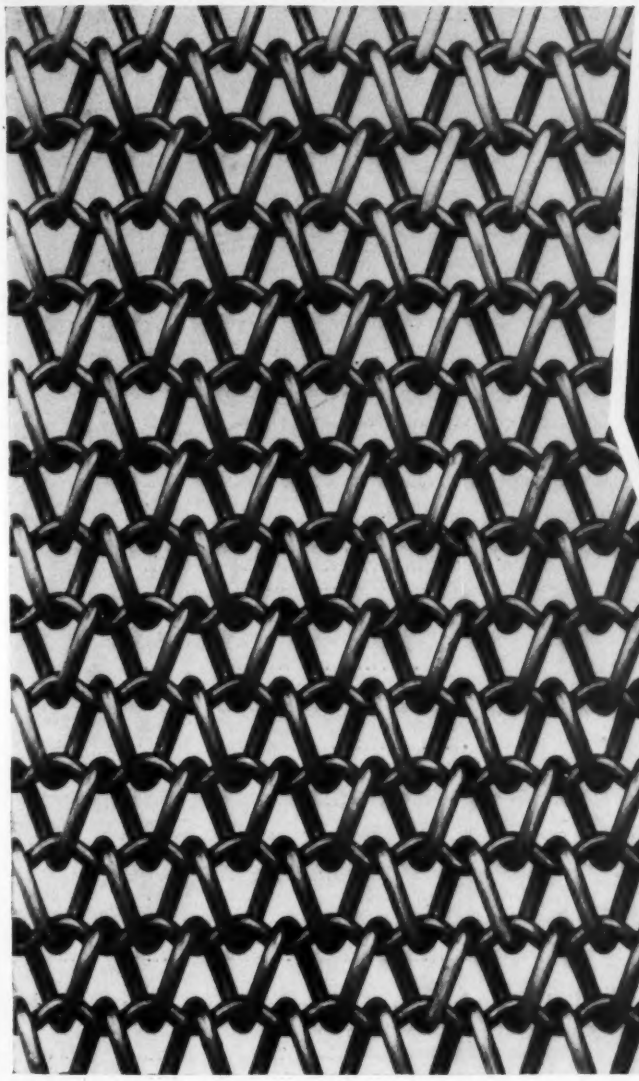
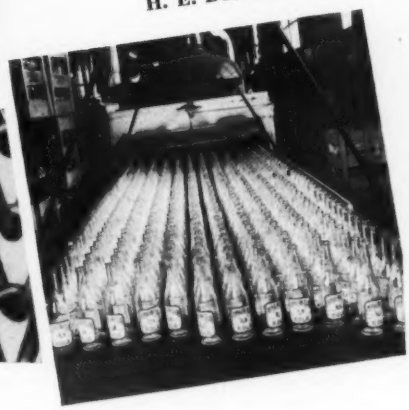


Fig. 7. 2,238,204: Woods: Fiber machine using a fluted rotating cone from which glass is blown by rings of blower jets 23 and 24.



Yours— Economical OPERATION *with* CAMBRIDGE Balanced Belts

Buck Glass
H. E. Decorating Lehr



WITH a Cambridge Balanced Belt installation, you can be certain of more profitable operation.

Here is why. These belts offer certain specific advantages because of their balanced construction. They are perfectly adapted for annealing all types of hollow glassware. Their construction eliminates creep, provides a perfectly flat carrying surface. They are so durable that they wear indefinitely, cut your maintenance and replacement costs. Yet, they are so flexible that they pass over any diameter pulley or driving drum.

Cambridge Balanced Belts are available in any specification to suit your individual requirements.

For information: wire, write or phone our nearest office.

CAMBRIDGE WIRE CLOTH CO.
CAMBRIDGE, MARYLAND
Boston - New York - Baltimore - Pittsburgh - Detroit - Chicago - San Francisco - New Orleans

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	43.00	46.00-49.00
Precipitated material		45.00	50.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)	lb.	....	....
Granulated	In bags, lb.	.0215	.027 -.0295
Powdered	In bags, lb.	.024	.0295-.032
Boric acid (H_3BO_3) granulated	In bags, lb.	.048	.054 - .0565
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.0865-.0875	.0925
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—(published list prices)			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	29.00	....
In bags	ton	30.60	40.00-42.50
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0835	....
In 5 Ton lots	lb.	....	.0875
Less than 5 Tons	lb.	....	.0925
Lime—			
Hydrated ($Ca(OH)_2$-MgO) (in paper sacks)	ton	8.50	8.50
Burnt (CaO-MgO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	9.00
Burnt, ground, in 180 lb. drums	Per drum	1.60	1.70
Kiln Dried ($CaCO_3$-$MgCO_3$) 10x30 mesh	ton	1.75	....
Kiln Dried ($CaCO_3$-$MgCO_3$) 16x120 mesh	ton	1.75	....
Nepheline Syenite, f. o. b. shipping point	ton	12.00	15.00
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4) in bags	ton	18.00-20.00	25.00
in bulk		16.50	
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls	Per 100 lb.	....	2.50-2.90
95% and 97%			
Bulk	Per 100 lb.	1.35	....
200 lb. bags		1.44	1.465
100 lb. bags		1.475	1.50

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.026-.029	.04
Aluminum oxide (Al_2O_3)	lb.	....	.09
Antimony oxide (Sb_2O_3)	lb.	.13	.13½
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04¼
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite, (20% Al_2O_3)	ton	9.00	12.00
Sodium fluosilicate (Na_2SiF_6)	lb.	....	
Tin Oxide (SnO_2) in bbls	lb.	.54	Open price.
Titanium Oxide (ceramic grade)			
In bags	lb.	.13	.13¼-.13¾
In barrels	lb.	.13¼	.13½-.14
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06½	.06¾
White Seal, 150 lb. bbls	lb.	.09	.09¼
Green Seal bags	lb.	.08¼	.08½
Domestic White Seal bags	lb.	.08¾	.09
Red Seal, bags	lb.	.07¾	.08
Zircon			
Refined Granular (Milled .01-.02c higher)		.06½	.07-.08

Coloring Materials

		Carlots	Less Carlot
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	1.10-1.15
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.22-.25
Chromite (99% through 200 mesh)	ton	45.00	48.50
Chromite ore (air floated)	ton	55.00	58.00-73.00
Cobalt oxide (Co_2O_3)			
In bbls	350 lbs. or more, lb.	....	1.84
	Less than 350 lbs., lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.19-.21
Black (CuO)	lb.	....	.18½-.20
Black prepared	lb.	....	.24
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.05-.09½
Black (Fe_3O_4)	lb.	.04½	.09
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls	lb.	....	.135
Lithium Carbonate	lb.	....	1.25
Manganese, Black Oxide (Caucasian)			
In Paper bags	ton	70.00	78.00
In Burlap bags	ton	71.75	79.75
In Casks	ton	74.00	82.00
Neodymium oxalate, 50 lb. drums	lb.	....	4.00
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals and Granular	lb.	.08¾	.09-.09¼
Powdered	lb.	....	.09¼-.09¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.21-.25
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06¾	.07-.07¼
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	.08¼	.08¾-.08¾
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.65
Yellow	lb.	....	1.65
Sulphur (S)—			
Flowers, in bbls	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	....	2.55
Yellow orange	lb.	....	1.65

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.072	.08
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	open price
0, 0½, ½, 1.	lb.	....	open price
Putty Powder	lb.	Open price.	
Rotten Stone, (Domestic)	lb.	02¼	.03½
Rouge, Red	lb.	....	.16
Black	lb.	....	.18

"Ceramic" COLORS and CHEMICALS are PRE-TESTED under actual PRODUCTION CONDITIONS

Glass Colors

Vitrifiable Colors for Banding, Spraying and Screening; Alkali-resisting, Acid-resisting, Satin Finish, High Fire Convexing, Low Fire and Squeegee Colors; White or Colored Weather-resisting Enamels; Colored or Crystal Ices.

Oils

Balsam Copaiba, Damar Varnish, French Fat Oil, Ground Laying Oil, Oil of Copaiba, Printing Oil, Squeegee Oils for Low Fire, High Fire or Overlapping Work, Venice Turpentine.

Chemicals

Aluminum Hydrate, Antimony Oxide, Barium Carbonate, Bone Ash, Cadmium Sulphide, Cerium Hydrate, Chromium Oxide, Cobalt Oxide, Copper Oxide, Iron Chromate, Iron Oxides, Fluorspar, Kryolith, Manganese Dioxide, Powder Blue, Potassium Bichromate, Sodium Uranate, Sodium Selenite, Selenium, Titanium Dioxide, Zinc Oxide.

"CERAMIC" colors are pre-tested for performance under conditions similar to those they must ultimately face in actual production routine.

The illustration shows laboratory assistants weighing up test mills. These are prepared in exactly the same way as production mills. Once prepared they are fired in laboratory furnaces under actual production conditions. Passing these fire tests for shade and workability is one step toward their being approved for shipment or for stock.

For smooth, efficient color operation, specify "Ceramic" laboratory-controlled Colors and Chemicals the next time you order.

"Ceramic" COLORS

CERAMIC COLOR & CHEMICAL MFG. CO.

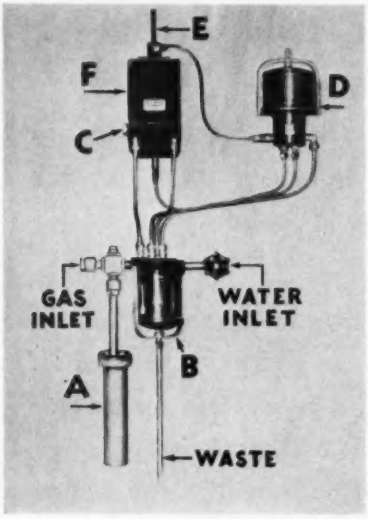
NEW BRIGHTON, PA., U.S.A.

NEW EQUIPMENT AND SUPPLIES

CAMBRIDGE OXYGEN RECORDER

A new oxygen recorder, using no chemicals, has recently been put on the market by the Cambridge Instrument Company, New York. The instrument operates from the electric supply line and provides continuous indication and graphic record of the amount of oxygen in any gas.

Gas is drawn in to the analyzer by a bubble-aspirator B, the condensate falling into a drip pot A. The aspirator maintains suction sufficient to draw a total quantity of about one liter of gas per minute through the inlet and the pubbling action also serves to scrub the sample. The gas is scrubbed and metered by the aspirator. The incoming gas divides into two streams, one of which flows directly to the aspirator, and acts as a line purge. The remaining gas flows through a secondary filter and orifice C, and to an inner bubbling tube in the aspirator. Pressure drop across the orifice as well as the flow through it, is constant. Within wide limits this flow is independent of both the total gas flow and of the restriction in the remainder of the apparatus.



Cambridge Oxygen Recorder

The gas sample is collected by an inner bell in the bubbler and from there it passes to one side of the analyzing cell D, then flows through tube E in the furnace, back through the other side of the analyzing cell and then to the bubbler aspirator where it goes to waste along with the main gas stream.

The center tube E of the furnace contains a carbon rod heated so that any oxygen in the gas passing over it is converted to CO_2. The supply of carbon in the furnace is usually sufficient for more than a week's operation, depending upon the oxygen content of the gas being tested. The carbon is automatically fed into the furnace. The flow of gas is controlled at a figure, which while conserving the carbon rod, permits rapid response of the apparatus.

One side of the analysis cell D is exposed to the original gas containing oxygen, while the other side is exposed to the same gas, with the exception that the O_2 has been converted to CO_2. The meter unit is arranged to measure the difference in thermal conductivity between the gases on the two sides, which is proportional to the oxygen concentration of the original gas. The result is not affected by any changes in the original CO_2 or N_2 concentration.

The standard range is 0 to 5 per cent oxygen on a 10″ scale, but the instrument can be scaled in ranges of 0 to 2 per cent oxygen full scale and 0 to 100 per cent oxygen full scale. Determinations by this recorder are not affected by variation in the constituents of the sample gas because a differential measurement is performed. Various analyzing cells may be combined so that the instrument will provide a complete gas analysis on one chart.

PNEUMATIC IMPACT CARRIER

A recent development in the materials handling field is a pneumatic roller, for carriers on belt conveyors, has been introduced by the Stephens-Adamson Manufacturing Co., Aurora, Ill. These Pneumatic Carriers, known as Style No. 711, are designed for use under loading spouts and in belt feeders where the impact of heavy bulk loads subject both conveyor belt and carrier to abnormal strains and wear. To cushion the impact of materials, the rollers are made up of a series of pneumatic rubber units, 6″ in diameter, for greater resiliency to shock and impact and increased life. The rollers are mounted on the steel hub in which bearings and shaft are housed. Roller units have thick. wear-resisting treads and are inflated and permanently sealed to prevent loss of air.

"NEOPHAN" LENSES

A special glass which is said to effectively absorb yellow (sodium) light rays is described in leaflet N 286 distributed by the Fish-Schurman Corp., New York. The glass, "Neophan," is recommended for glass blowers, aluminum welders and for any welding or cutting operation where an intense yellow flame is encountered. The glass owes its absorbing power to certain rare earths and is a light pinkish tint in color and permits the rest of the visible spectrum to pass with little change. The lenses reach their optimum effectiveness at a thickness of only 2 mm. The lenses may be had mounted in goggles or can be furnished flat, ground and polished, or in the form of ophthalmic blanks.

ALL-GLASS TAPE

Fiber glass adhesive tape, with a pressure-sensitive coating, has recently been developed by the Industrial Tape Corporation, New Brunswick, N. J. The woven glass textile is the same one developed by the glass companies and finding steadily increasing uses in many industries. The new product will have a number of uses in the electrical industry and for insulating other than electrically. The tape is manufactured in rolls in the full width of 40 inches and then cut into any desired widths, exactly as paper-backed and cloth-backed tapes when cut. In use by the consumer it is applied and cut just as any other adhesive tape.

CATALOGS RECEIVED

Brown Instrument Co., Philadelphia, Pa. Catalog No. 77-1, "Brown and Minneapolis-Honeywell Industrial Power Units and Motorized Valves." This catalog describes and illustrates a line of motor power units and motorized valves. Photographs are shown of electric control motors, slip stem globe type, rotary stem globe type, butterfly type, pilot operated, three-way and special valves.

Permochart Company, Sewickley, Pa. A four page folder on their Vinylite plastic "Permochart," a recording instrument chart designed for continuous reuse. The folder contains information regarding chart construction, details, installation and prices. A sample chart is enclosed to illustrate how daily ink record is easily removed from the chart surface, enabling continuous chart reuse.

The DeVilbiss Company, Toledo, Ohio. A new catalog, "I E," covering in condensed form its complete line of spray-finishing equipment for industrial use. The new catalog replaces catalog "ID-A," and brings all prices and specifications up to date.

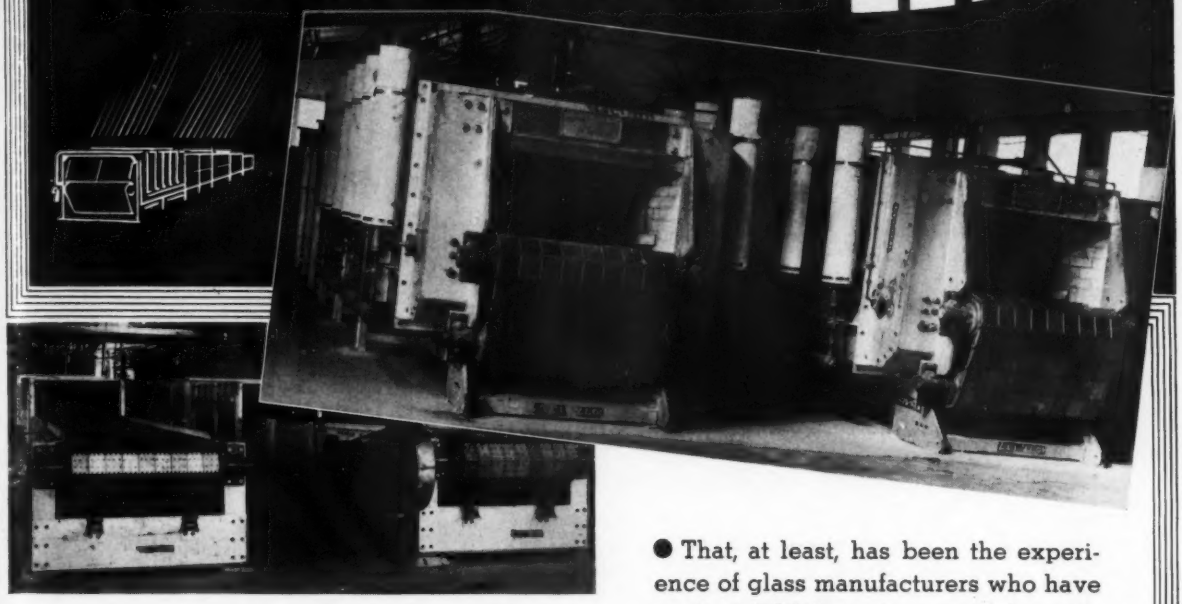
North American Refractories Co., Cleveland Ohio. Bulletin No. 103, "Insulating Fire Brick." A 12 page booklet with tables, graphs and technical data on Narco Insulating Fire Brick.

Electric Machinery Mfg. Co., Minneapolis, Minn. A 12 page publication, "Magnetic Variable-Speed Drives," presenting the principles, characteristics, advantages and constructional forms of magnetic drives.

CATALOG & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins reviewed in this department may be obtained by writing to THE GLASS INDUSTRY.

To investigate the FIROLL FEATURE is to recognize the TECO AS A DEFINITELY SUPERIOR LEHR



Illustrated above are the loading and discharge ends of two recently installed TECO LEHRS designed for the annealing of bottles.

Each is 83 feet long, equipped with a 3 foot belt and fired by natural gas.

● That, at least, has been the experience of glass manufacturers who have studied TECO design and taken the time to consult users as to consistency of performance and cost of fuel.

The FIROLL method of firing from alternate sides inside the rolls that carry the belt, and the use of the "sting out" to heat the side walls give economical consumption of fuel.

The FIROLL method of heating also permits close control of heat at various positions and makes practical exceptionally accurate maintenance of the desired temperature gradient.

The PANWELD Belt consisting of a multiplicity of formed and welded steel pans, provides a flat surface that minimizes the possibility of marking or checking of the ware.

Write for bulletin illustrating and describing the above and other distinctive advantages of TECO annealing and decorating lehrs.

TOLEDO ENGINEERING Company

GLASS MELTING *and* MANUFACTURING EQUIPMENT

EASTERN OFFICE 220 E. LEXINGTON ST. BALTIMORE MD. • • • 958 Wall St. TOLEDO, O.

A view of the new window glass factory which has just been placed in operation by the Industrial Glass Works Company, Ltd., St. Laurent, Montreal, Canada. The plant is equipped with four sheet glass drawing machines and production is to include window and heavy drawn glass. This is the only sheet glass factory operating in Canada.

DISCUSS CERAMICS IN ARCHITECTURE

A symposium on "Ceramics in Relation to Architecture" was combined with a dinner meeting of The New York Society of Ceramic Arts, May 12, in New York City. Lawrence E. Barringer, president of the society, chided the architectural profession for neglecting to see and utilize more fully a material that offered so much versatility in decoration—ceramics. Even though ceramics have been used for archiectural ornamentation since earliest days, he argued; yet, at a time when architects are searching as never before for decorative media to relieve the severity of modern art, they neglect the possibilities of color and texture to be found in ceramic products.

Mr. Rambush, architect, suggested in reply that one reason might be found in the architect's need for infinitesimal accuracy in building materials, whereas ceramics are more apt to vary as to dimension. Joep Nicolas, Dutch artisan renowned for his stained glass windows, felt that the variations Mr. Rambush described were not a liability but one of the assets of the material. He stated that a trend away from absolute smoothness of surface toward a rougher tile, had already become noticeable. John Ogden, publisher of THE GLASS INDUSTRY, suggested that both viewpoints might become reconciled if one kept in mind the axiom of suiting the material to its proper setting. He stated that glass had become such a versatile material these days that it could be utilized successfully in almost any environment.

Sculptural ceramics executed by public high school students were shown at the meeting by Miss Mabel F. Brady, instructor in this subject. The figures were crude, but they revealed imagination and power of observation. Subjects like organgrinders, cowboys and street scenes were favorites. Evidently the students are not hampered by inhibitions so the characters were rather overdrawn, but all the more realistic. A social slant to ceramic instruction for youngsters, Miss Brady said, is that even the most unruly elements among them will sit down and become interested.

GLAUBER'S SALT

A Limited Supply Available for Early Delivery

SODIUM SULPHATE
SALT CAKE • SALT

Write for Analyses and Prices

DESERT CHEMICAL COMPANY
4031 GOODWIN AVE., LOS ANGELES, CALIF.

• Gov. John W. Bricker on May 15 announced the appointment of W. E. Levis, chairman of the board of the Owens-Illinois Glass Company, as a trustee of the Archaeological and Historical Society of Ohio.

BATTELLE LABORATORY EXPANSION

A $35,000 extension of laboratory facilities is in progress at the Battelle Memorial Institute, Columbus, Ohio. This expansion is the result of increased research for industry, occasioned partly by the defense program, but mainly by new products research. Eighteen new laboratories and offices, totaling nearly 10,000 square feet, are being installed. They will take care of forty additional research engineers. The majority of these laboratories are in the new laboratory building which was completed only a year ago.

REMOVING MOISTURE FROM COMPRESSED AIR

(*Continued from page* 249)

looked is that all the compressed air for a plan should go through aftercoolers. This includes the output of standby compressors, etc.; as a small unit, run only a few hours on a moist or humid day (without an aftercooler), may put enough moisture into a compressed air system to cause faulty and erratic machine operation for a number of days. In some plants it is economical to use one large aftercooler to handle several compressors; in others, due to plan layout, etc., it may be more economical to use an aftercooler per compressor.

IMPORTANT CHANGES AT CORNING

Amory Houghton, president of the Corning Glass Works since 1930, became chairman of the Board of Directors and chairman of the executive committee by action of the Board of Directors May 16. Glen W. Cole, vice president, was elected president.

The change of officers is accompanied by changes in the by-laws whereby the chairman of the board is the chief executive officer of the company, and the president and executive vice president are the principal operating officers. The office of executive vice president went to George D. Macbeth, a vice president. Alexander D. Falk, former president and board chairman, now becomes honorary chairman of the board. Alanson B. Houghton, also a former president of Corning, and who has been chairman of the executive committee, is now honorary chairman of that committee.

William C. Decker, who has been comptroller and assistant to the president, was elected vice president. H. R. Moorhead, Jr. for the past two years assistant general manager of the Macbeth-Evans Division of Corning, becomes assistant treasurer. William W. Sinclaire, cashier, was named assistant secretary.

DISCUSSION ON CONTEMPORARY MATERIALS

A discussion on contemporary materials was held May 6 at the Columbia School of Architecture, Columbia University, New York. The entire session was devoted to glass and some unusually splendid addresses developed many ideas and much information that was of interest to an audience composed largely of the architectural profession. As the prospectus of the meeting stated, "These conferences are designed to afford the profession and related interests an opportunity to survey the advances already made and to consider the changing concepts of a static and structural design which are inevitable when these new materials are fully and properly utilized."

R. A. Miller, Pittsburgh Plate Glass Company, opened the discussion on glass with "Manufacture and Use of Glass." Other speakers were H. Crefton Domer, Libbey-Owens-Ford Co., "Glass, Light and Color"; Henry Wright, Associate Editor Architectural Forum, "Architectural Significance of Glass"; and Richard F. Bach, Metropolitan Museum of Art, "New Days—New Ways; the Designer and His Material."

FOR SALE

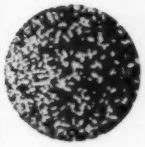
300 tons tableware tank crystal cullet at $12.00 per ton—FOB the factory—Dunbar, West Virginia.

The Dunbar Glass Corporation

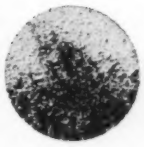
"Re-tooling" Glass Production

MODERN GLASS is the result of new, improved technology—and new types of basic materials. Here are outstanding factors in this "tooling up" of glass production — all BETTER MATERIALS produced by Solvay:

SOLVAY DUSTLESS CALCINED POTASSIUM CARBONATE 98-100%
Especially developed by Solvay for the glass industry. Used to produce special glass such as optical glass and fine stemware, this product was a major development for the glassmaker. Dust from potassium carbonate is a serious nuisance to workers and is particularly damaging to the costly glass furnaces. It decreases the life of expensive fire brick, lowers the efficiency of heat transfer and otherwise seriously interferes with equipment and processing. Solvay Calcined Potassium Carbonate *is free from dust* and therefore prevents costly losses. Its "homogeneous" physical characteristics, as in the case of Solvay Dustless Dense Soda Ash, result in important production savings.



SOLVAY DUSTLESS DENSE SODA ASH—*Especially developed by Solvay for the glass industry.* Highly pure, highly uniform, for all practical purposes free from dust. Dust interferes with processing and is a source of irregularities in the glass. Physical characteristics of this product are so determined with respect to density and granulation, that there is perfect blending with other ingredients to produce a purer glass. Prevents loss of valuable materials and helps maintain control over glass melts, which is an important key to quantity production.



SOLVAY GRANULAR HYDRATED POTASSIUM CARBONATE 83-85%
This form of Potassium Carbonate is available for those who prefer a hydrated type. A high quality granular product, also essentially free of dust.

AN OUTSTANDING TECHNICAL SERVICE FOR GLASSMAKERS—Solvay is particularly well equipped to render technical assistance on glassmaking problems as they relate to the use of alkalies. Prompt and individual attention by recognized glass technologists is given all inquiries.

★ ★ ★ ★ ★ ★

SOLVAY SALES CORPORATION
Alkalies and Chemical Products Manufactured by The Solvay Process Company
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New Orleans • New York • Philadelphia • Pittsburgh • St. Louis • Syracuse
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STAINED GLASS (*Continued from page* 254)

these glasses was a frequent happening; also, that the people who made the glasses transported them to other people who worked them into stained glass windows. That may prove that already in the 14th Century both of these activities were more or less separated from each other. However that may be, the glass manufacturer as well as the independent stained glass artist in France until this very day have been called "*maitre verrier*," a title which has conserved a traditional pride, reminiscent of the glorious standing of these "*gentil hommes verriers*" in the Middle Ages.

Theirs was a glorious standing and they played a great part in the cultural history. As soon as the possibilities of figured decoration in the stained glass windows appeared, they became for centuries outside of Italy (where the "affrescho" technic was at home) the chief interpreters of the biblical mysteries and of the wonderful stories of saints and martyrs. They were the transmittors of the enormous stock of hierography and iconography in which they found all the rhythms and expressions of human feelings. They translated the formulas of old mosaic and miniature drawings, they used them and enriched them in endless variations. Withal there was a beautiful uniformity in their work in the early ages of the 12th and 13th centuries, chiefly because the making of different glass colors was rather limited. We may count nine or ten prevalent colors, which are repeated in every window and which constitute the whole palette of Chartres, Bourges and of the Sainte Chapelle.

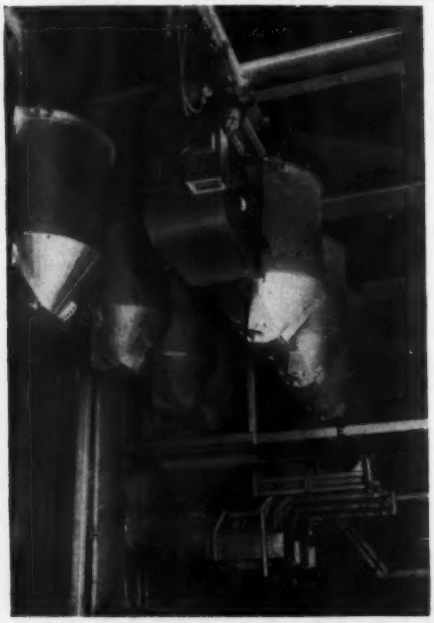
About these colors were woven so many and such incredible stories that most of the half-cultivated people even now speak of secrets and unbelievable proceedings necessary to obtain these twinkling marvels. In the so-called scientific records of these times, like the chronicles of the Abbey of St. Denis, like the famous book on the arts by the learned monk Theophilus: "*Diversarium Artium Schedula*," we find formulas for the making of the colored pot-metal, but given behind a mask of ridiculous alchemy, in the way the artist liked to hide his knowledge.

These records speak of great quantities of precious stones and noble metals ground and added to the mass of the melting glass: sapphires for blue, rubies or gold for red and pink, and silver for yellow. But all these tales are fiction invented by the glass makers to protect their real secrets. We know that blue is made from cobalt oxide or even from copper and that the tale of sapphire originated because at that time they called cobalt "saffre," since it seemed to have some relation to sapphire.

The most useful metal was copper, named "oes ustum" and later "ferret d'espagne," with which in different chemical combinations they could obtain various colors; like light blue, green and ruby. Manganese made purple, pink and violet-brown. Iron, scientifically called "crocus martis," was a valuable medium to modify colors.

It is not these "secrets" which should prevent us from making beautiful windows. We can obtain all the colors we like. There is no secret lost to us; our modern chemistry is able to perform all the miracles and to reach every intensity of color. The only loss is psychological.

First: the Bible of the poor (biblia pauperum) was much richer an iconography than the all-too-cerebral stories we are told about Christ and His Saints. And the unrestricted, direct and living way of relating by simple pregnant gestures and dramatic compositions was a medium lost to our too analytic and too eclectic mind.



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Until late in the middle ages the miniaturists had hidden themselves in the libraries of monasteries and palaces, making precious and colorful drawings in the prayer-books of abbots, emperors and dukes. Then at once they started painting large wooden panels and altar pieces, and they took over the part of the glass painter as narrators of all the Christian knowledge. The glass painter saw his supremacy gone; these new painters were daring realists and their panels gave much more thrill to the people than the windows possibly could do. How to live up to this, how to keep pace with this free new art?

The craft of the glass painter was a very limited one; how could one give tactile values of fabrics and complexion through this simple medium of primary colors with fired-in black lines and shades? There had to be found new means to express more than one color in one piece of glass. And so the use of silverstain was originated. Another innovation was the technique of etching away one color from a double layer glass. There were such glasses in various combinations: a thin layer of ruby on white, on yellow, on green, on lavender, on blue. There was blue on white, and on yellow; there was green on white; brownish pink on white, and perhaps some other compositions. In covering the surface partially with wax and exposing the uncovered parts to the action of hydrofluoric acid, a certain design was etched off in the color. There was the cobalt blue, which could be fired in. And last but not least, the rouge "Jean Cousin" or flesh red, a very refined red earth or sanguine.

Parallel with these possibilities the practicing of the grisaille painting; that is, the art of shading with black, made immense progress. Not only the black became more manageable as a shading substance to render light and shadows in a real plastic effect, but also, through different frilling, they learned to make this same copper oxide assume various colors. We have a cool greenish variety, a bluish gray back, a "caput mortuum" violet brown and a bistre brown. Of course, they are not enamels; they are not transparent colors; and they always will act as a light-subtracting substance. But the different colors in the shadings make them more suitable to give a special tonality to a window or to a part of it.

So we find in the beginning of the 16th century the pictorial means of expression largely improved.

There are many people who consider the 13th century the apex of glass painting and therefore confine their sympathy to the orthodox way of making a mosaic in colored glasses, with the only illustrative element the black trace and a thinner shade of the same fired into the glass. They condemn, or at least do not appreciate all the later refinements; and they consider the beginning of the decadence as dating from the first great names in the history of glass painting.

For my part, I have another conception: one could no more compare a Byzantine Icon to a Titian or a Greco; nor the "Notre Dame de la belle Verriere" to a window by Jean Cousin, Nicolas de Troyes or van Orley. In all the arts, history furnishes a parallel. All developments tend from impersonal to personal, from strong and primary to refined and specialized, from undifferentiated to subtle and differentiated expression. So is the history of stained glass. And considering the splendid achievements of the 16th Century, especially in Holland and Belgium, I would not dare to speak about decadence, any

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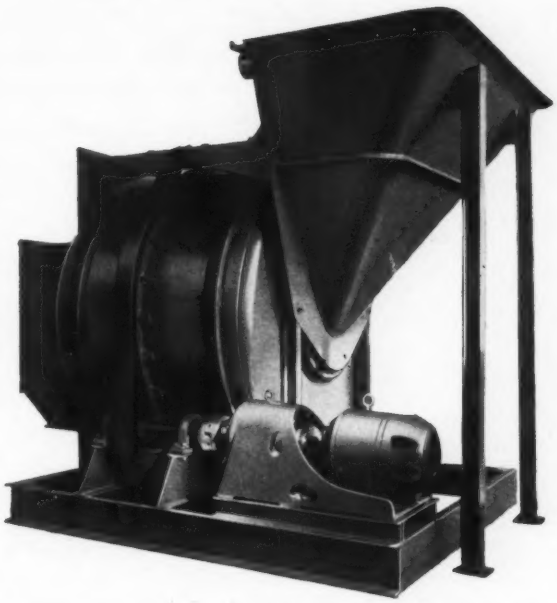

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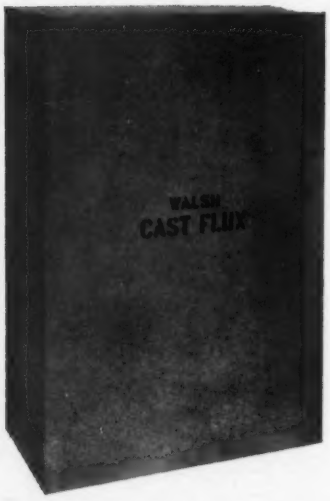

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more than I should dare to minimize Rubens, or Tiepolo compared to Giotto and Memlinc.

Whoever has seen the glorious windows in the Saint Gudule in Brussels, or the fifty-five enormous masterpieces of the Crabeths in St. Johns at Gouda in Holland, cannot just ignore or minimize the Baroc glass art. Some theorician may object that perspective in glass windows is nonsense; but why shouldn't he also object to perspective in a tapestry design or in a mural painting. Real criticism is not that easy. The fact is the 16th Century glass masters show us a craftsmanship that never has been surpassed. Mastery in design—mastery in the making of the glasses, in painting their grisaille and their stains, and then mastery in firing—all that is clearly to be found in their windows.

We cannot speak about decadence until a century or even a longer period has elapsed, when less and less the glass painters took the trouble to use colored glasses, but substituted beautiful and bright enamels. These had the advantage of easy handling and easy firing, but the great and disastrous disadvantage of nonpermanence. In the long run these peeled off, because they did not have the same expansion coefficient as the glass itself. Of course, the enamels on glass were then quite new; the artists who applied them did not appreciate the consequences. And when these consequences became apparent it was too late. The manufacture of colored pot-metal was nearly forgotten; nobody had asked for it for almost a century. Then the destiny of stained windows came to its last and bitter fulfillment: the plain white pane.

Poverty only is the reason why a lot of splendid old windows are left: they did not have enough money to put white panes in their places. At the end of the 18th century, the art of stained glass painting, once the greatest and most popular branch of decoration throughout Europe, died completely.

Came the first big industrialization of the world: the 19th century. Baroc and Rococco and all the Louis styles were dead; the wave of Napoleon's Empire classicism was ebbing low into homey Biedermayer; machines were everywhere carving and casting ornaments—lions and lilies, festoons and garlands of every style and of none.

In this frightful warehouse of bourgeois wealth the Romantics cultivated their nostalgia toward something more serious, something with a little more tension and a little more bearing. And so Viollet le Duc had the courage of rediscovering the Gothic. That was not easy at all.

One of his first monuments is a rotunda, which tries to be gothic but looks really a little fishy. This monument is very interesting in the history of stained glass; for from there starts the resurrection of this art. I am speaking of the mausoleum of the d'Aumales and Orleans at Dreux. We see in this circular building some horrible enamel windows, imitating moonlight effects and showing other stunts and tricks; but we see also six windows done by none less than Ingres, and in the crypt there are two of them by that other great painter Delacroix.

The latter's windows are beautiful in draftsmanship and composition, but they are done in enamels that are peeling off. The Ingres windows are rather full and cold, but they are the first for which colored pot-metal was made after the lapse of a century, and they are prototypes of the course the craft would take under the influence of the new gothic tendencies in architecture and decoration.

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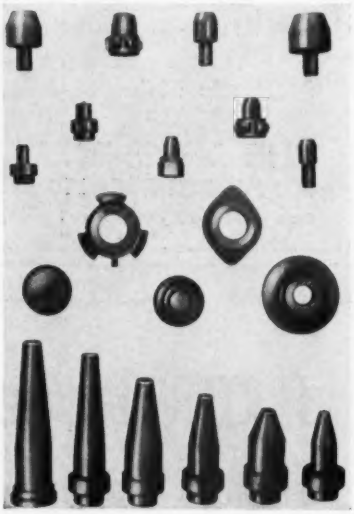

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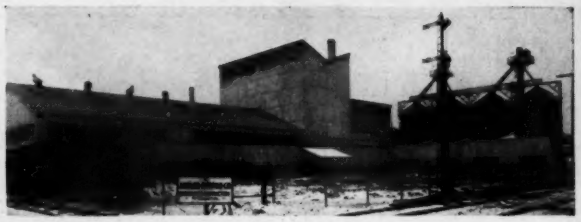

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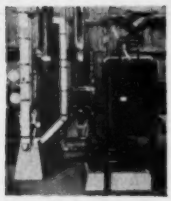

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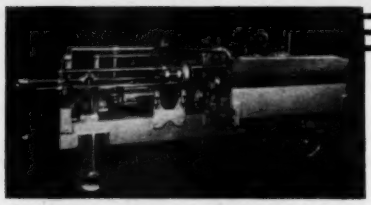

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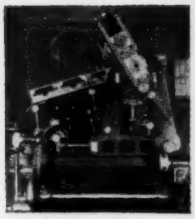

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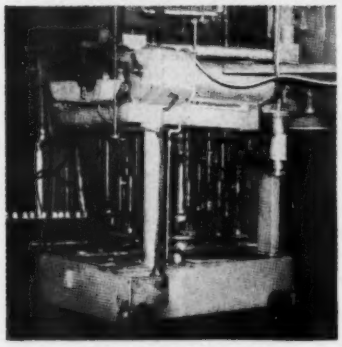

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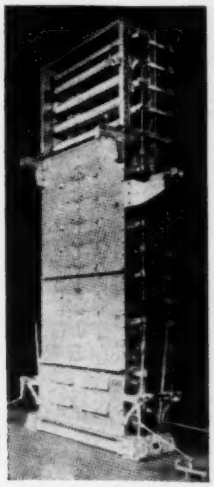

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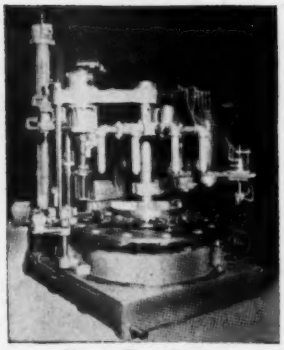

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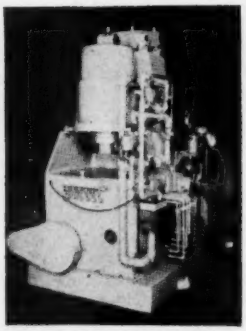

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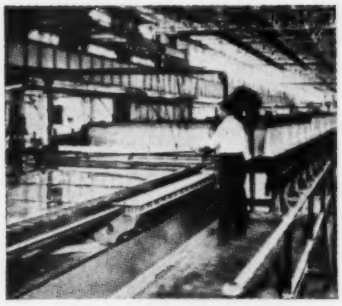

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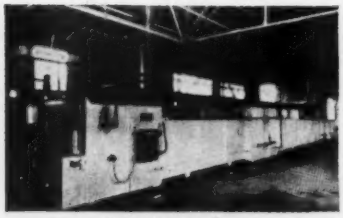

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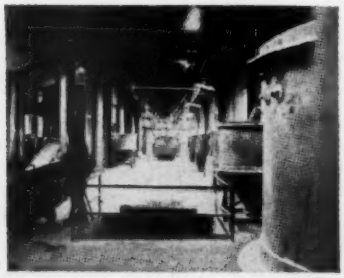

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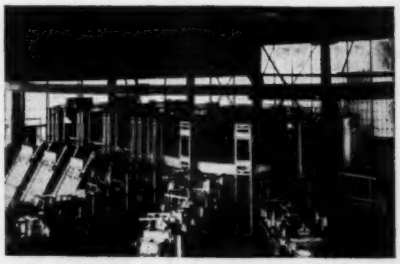

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